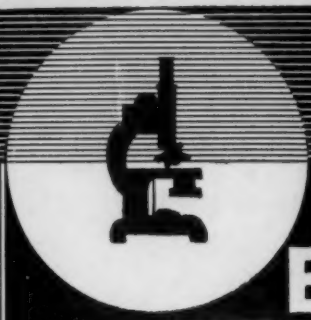

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3. The title of the article should be in capitals across the top of the page. The name, professional connection, title, and business address of the author should be entered below the title.

4. Explanatory notes will be printed as footnotes. Such notes should be as few as possible. They should be indicated on each page of the manuscript by the use of superior symbols in the order given: the asterisk (*), the obelisk or dagger (†), the double dagger (‡), the section (§), and parallels (‖). The materials for footnotes should be inserted on separate lines following the words or sentences to which they refer and should be separated from the text by horizontal lines. They should not be placed at the bottom of the page.

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5. Each reference to the literature is to be designated by a superior number. The number should follow the name of the author, when this is given, or be placed in the topical sentence which introduces the paraphrase but should be located at the end of a direct quotation when such is used. The numbers used will be in sequence throughout the article. All of the references with the specific citations will be arranged numerically at the end of the article under the heading REFERENCES CITED.

(a) References to articles in periodical journals should follow the style used in the journal both in the abstract section and at the end of articles.

(b) References to books and monographs should follow the style used in the New Publications section of the journal but should not include the price of the publication.

In general references to books should include (1) name of author (family name first), (2) title of book (underlined), (3) edition and volume (if more than one), (4) address of publisher, (5) name of publisher (in full), (6) date of publication, (7) pages (total number of pages if entire book is referred to or exact pages in the book if the citation is to specific pages). *It is very important that all citations be definite, complete, and accurate.*

6. Quotations of less than five lines should be enclosed in quotation marks and placed regularly in the lines of the manuscript; quotations of five lines or more should be single-spaced, indented three spaces, and be without quotation marks. When any part of the reference is omitted from the quotation, the omission should be indicated by a series of dots, (. . .).

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2. Method
3. Findings (or Conclusions)

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(b) Photographs should be in sharp contrast, should have a glossy finish, and should be at least three inches in the shorter dimension.

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TABLE III

NUMBER OF NURSERY SCHOOLS IN UNITED STATES

State	Number of Nursery Schools	State	Number of Nursery Schools
California	14	Missouri	1
Connecticut	3	Nebraska	1
Dist. of Columbia	2	New Hampshire	1

11. It is planned to print articles directly from manuscript and not to submit galley proofs to the author. Several leading journals now follow this practice and find that it saves time and expense as well as insures a better printed product. The plan necessitates, of course, that the manuscript be complete, accurate, and well-typed.

12. Manuscript for October issue must be in the hands of the Editor by July 10; for December issue by October 1; for February issue by December 1; for April issue by February 1.

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Volume XVI DECEMBER, 1931 Number 2

Some Results for the Test of Scientific Thinking

SAM STRAUSS
Akron, Ohio

Purpose and Plan of the Investigation

This paper presents the results of an attempt to measure the skill of high school students in their use of certain of the elements of scientific thinking. Downing's test, *Some Elements of Scientific Thinking*,* was used for this purpose. The test consists of fifteen parts or problems, each of which tests one element of scientific thinking or one of the safeguards to be thrown around the process. The test is broad enough to cover the field thoroughly, simple enough for high school pupils to take, and brief enough to be administered in a single high school class period of forty-five minutes.

Method of Procedure

The test was administered in March, 1930, to 1,343 pupils in the 8th, 9th, 10th, 11th, and 12th grades in Garfield High School, Akron, Ohio. Each pupil's paper was scored by simply counting the number of errors he made on each problem. The pupils were then divided into three groups. Group "A" consisted of those who made no errors or very slight errors

* Published by E. R. Downing, The University of Chicago, Chicago, Illinois.

on any problem, and who may be said to have shown mastery. Group "C" included those who made serious errors on any problem. The other pupils were lumped into group "B." Each problem was considered individually, so that any pupil might be in group "A" in some problems, in group "B" in others, and in group "C" in the rest. The size of the groups also varied from problem to problem.

In finding correlations between the test and the intelligence of pupils, it was necessary to rank the pupils on their answers to the test as a whole. This was done by assuming that each problem in the test was of equal weight, then assigning a value of 1 to group "C," 2 to group "B," and 3 to group "A." The total number of points on the test was assumed to be the pupil's score. The scores were correlated with the scores of the same pupils on a general intelligence test of recognized merit.

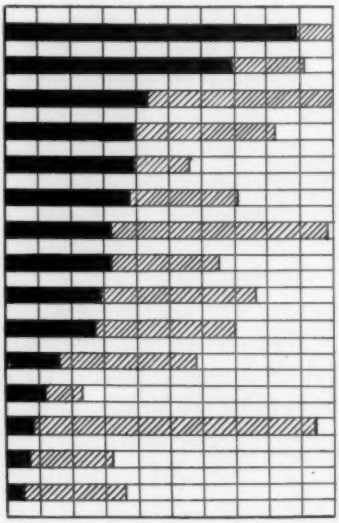

Figure 1.—The ranking of fifteen elements of scientific thinking in their order of difficulty for 1343 high school pupils: Group "A" (solid bars), Group "B" (shaded bars) and Group "C" (white bars).

Results

1. *Which of the elements of scientific thinking are practiced most? Which least?*

The ability to recognize a problem, the ability to observe (i.e. two of the first steps in the thinking process) seem to be the best mastered of the elements studied. On the other hand, the ability to reason, to analyze,

and to see essential relationships seem to be the least developed of these processes. The remaining elements fall between these two. It was noticeable that while the ranking of the mastery, or "A," group of pupils is in a certain order, the poorest, or "C," group do not rank in the reverse order, as would be expected. (See Figure 1.)

2. *Do boys think better than girls?*

In a comparison made between the thinking abilities of 676 boys and 667 girls, it was found that, in general, there is but little difference between them. In some elements the boys exhibit greater ability, in other cases the girls appear superior, but in no case is the difference more than 10 per cent. The differences in superiority were balanced against each other and it was found that on the average the boys surpassed the girls by slightly more than 1 per cent on each problem.

3. *Does scientific thinking improve with rise in grade status?*

The results of each of the fifteen problems were carefully examined to discover if pupils grew in their ability to think as they advanced from the 8th to the 12th grade. Considering only the number of pupils who were in or who later reached to the status of group "A," it was found that the improvement ranged from −7 per cent to +62 per cent on the different problems. On the whole the increase in size of group "A" during the four years was 22 per cent. Six per cent increase was shown during the first year, 7 per cent increase during the second, 5 per cent during the third, and 4 per cent during the last year of school. In other words, more pupils increase in their power of scientific thinking during the 10th grade than in any other, and the least increase comes in the 12th grade, though the differences are slight.

This measures the increase in the number of pupils who achieved mastery but it does not indicate what happened to the other groups. Upon analysis it was found that the "C" group decreased 22 per cent in number during the same period, while the "B" group remained the same in size. In other words, 22 per cent of the poorest group of pupils increased in their ability to think sufficiently to move into the middle group, while 22 per cent of the middle group improved to the extent that they could be classified in the highest group. Altogether, 44 per cent of the pupils improved in their ability to think scientifically to such a degree that the improvement was marked enough to measure; the remaining 66 per cent showed no measurable rise in thinking skill, though they were also subjected to an extended period of training in high school, one of the chief purposes of which is supposed to be to train pupils to think.

As a partial check on these results, the same test was administered to

161 students in the Teachers College of the University of Akron. It was found that while the freshmen in the college group showed an increase in the size of the mastery group of 6.8 per cent over the pupils in the 12th grade, there was little improvement during the subsequent years. Among these college students from 51 to 54 per cent, or slightly more than half of the group, showed that they had mastery over the fifteen elements of scientific thinking on which they were tested. The changes in the size of the mastery group on various grade levels are shown in Table I.

4. *Does scientific thinking improve with increase in chronological age?*

While a distinct improvement is shown by pupils as they advance from one grade to the next, there is no such marked change with increase in age. Between the ages of 13 and 18, a period of 5 years, the size of group

TABLE I

CHANGES IN THE SIZE OF THE MASTERY GROUP WITH THE CHANGE IN GRADE STATUS

	High School					College			
Grade	8	9	10	11	12	13	14	15	16
Number of pupils tested	277	449	277	199	141	83	47	21	10
Average per cent in "A" group	22.6	28.6	35.6	40.5	44.6	51.4	51	54	52

"A" increases 9.6 per cent, or less than 2 per cent for each year. If the comparison be made between the 12-year olds and those who were 19 (there were only 4 of the former and 16 of the latter), the increase in the

TABLE II

CHANGES IN THE SIZE OF THE MASTERY GROUP WITH THE CHANGE IN CHRONOLOGICAL AGE

Ages	12	13	14	15	16	17	18	19
Number of pupils tested	4	152	304	355	264	181	65	16
Average per cent in "A" group	30	27.8	30.5	30.3	34.9	36.5	37.4	32.4

size of group "A" is only 2.4 per cent. Practically all of the increase in ability appears to come between the ages of 13 and 14 (2.7 per cent), and 15 and 16 (4.6 per cent). Between the ages of 12 and 13, and between 18 and 19 there seems to be an actual decrease in the size of the best group of thinkers. In short, as shown in Table II, the age of a pupil appears to have relatively little to do with his mastery and use of the elements of scientific thinking.

5. *Is there any relationship between general intelligence and the ability to think?*

To find the relationship between general intelligence and the ability to think, a correlation was made between the intelligence quotients of a group of 90 pupils in the 10 B grade, as determined by the Otis Intelligence Test, Higher Examination, and the individual scores on the Downing Test of the same pupils. It was found that the correlation was .64 $\pm$.04, indicating that there is some relationship between thinking and general intelligence, though this relationship is not very marked.

Summary

Though this investigation is by no means a final answer to the question of how well pupils think and what errors they make in their thinking, yet it gives, in a measure, a hint of what the actual situation may be, and suggests that this is a worthwhile field for further research.

In the study of 1,343 high school pupils who took the Downing test it was found:

(1) Not all of the elements are equally well mastered, or used equally well. Some are handled much better by most pupils than are others.

(2) There is almost no difference between the thinking ability of boys and girls.

(3) Forty-four per cent of the pupils show a noticeable improvement in their thinking ability during the interval between the 8th and 12th grades. There is an increase of 22 per cent of the pupils who advanced in the best group of thinkers who show mastery. This increase is about equally distributed through the high school years, and continues at approximately the same rate into college.

(4) Among the chief group of pupils considered, those from 13 to 18 years of age, less than 10 per cent show an increase in their skill in the use of the elements of scientific thinking. The increase is unevenly distributed, most of it coming between the ages 13 to 14, and 15 to 16. It may fairly be said that, generally speaking, pupils do not become better thinkers because they grow older.

(5) In a group of 90 pupils taken as a fair sampling, there is a positive correlation of .64 $\pm$.04 between ability to think and general intelligence.

Natural Science Education in German Elementary Schools—II*

LOIS MEIER SHOEMAKER
State Teachers College, Trenton, N. J.

Program and Aims for Natural Science

In all German elementary schools natural science takes its place as a subject of the curriculum in the fifth grade. Some form of natural science is taught in every grade from the fifth through the eighth, which marks the close of the period of regular school attendance for approximately seventy per cent of the German school children. As already stated, preparation has been made in the *Heimatkunde* of the *Grundschule* for the science study which follows in the four upper grades of the elementary school. About one-tenth of the total curriculum program is devoted to natural science in Prussia.

A comparative compilation of the programs for natural science in the elementary schools of various states for both boys' and girls' classes is given in Table II. The last column in each case indicates the per cent of the total number of hours in the school program for the four grades which is devoted to natural science. A study of the figures in Table II shows considerable variation in the number of hours devoted to instruction in natural science each week, ranging from a minimum of two in the fifth grade to a maximum of five in the eighth grade. From two in the fifth grade to three or four hours in the remaining three grades seems to be a customary allotment of time. There is no significant difference in the boys' and girls' programs.

For comparative purposes the suggested programs for natural science in three American states have been set up alongside that of the required program for the German state, Prussia (the latter program has been reduced to minutes per week for purposes of comparison). The American programs given have been selected as typical for other American states.

A comparison of time allotments in the three American states shows little agreement as to the amount of time which should be devoted to natural science education in elementary schools. In making a comparison with the Prussian time allotment it must be remembered that the natural science material in German schools is a part of an integrated study involving geography and history, which are taught as separate subjects in most American schools.

*Part I of this article appeared in the October issue of SCIENCE EDUCATION.

TABLE II

PROGRAM FOR NATURAL SCIENCE IN THE FOUR UPPER GRADES OF THE ELEMENTARY SCHOOLS IN THE VARIOUS GERMAN STATES [6]

State	Grade					Percentage of Total Subjects
(Boys' Schools)	5	6	7	8	Total	
Baden	2–4	2–4	2–4	2–4	8–16	6.3–12.5
Bavaria	2	2	3–2	3–4	10	8.6
Hamburg	4	3	3	5	15	11.9
Hesse	2	2	3	3	10	7.8
Prussia	2	3–4	4	3	1213	10.2
Saxony	2	2	3	3	10	8.8
Thuringia	2	2	4	4	12	10.3
Württemberg	2	2	4	3.5	11.5	10.2
(Girls' Schools)						
Baden	2–4	2–4	2–4	2–4	8–16	6.3–12.5
Bavaria	2	2	3–2	2	9–8	7.5– 6.7
Hamburg	3	3	3	4	13	10.3
Hesse	2	2	3	3	10	7.8
Prussia	2	2–3	3	3	10–11	8.9–10.7
Saxony	2	2	3	3	10	8.8
Thuringia	2	2	4	4	12	10.3
Württemberg	2	2	3	3.5	10.5	11.9

Figures in the last four grades are more comparable. There is no agreement between American states as to time allotment for natural science. The Prussian elementary schools, and all other German schools (see Tables I and II) give more time to natural science education than do American schools. In this connection the reader must also remember that natural science education is compulsory in all German schools, whereas in American schools natural science education is voluntary in most states and the decision rests with the individual cities as to whether it shall be a subject of the curriculum. In California where a number of progressive cities are

TABLE III

PROGRAMS FOR NATURAL SCIENCE IN VARIOUS STATES IN MINUTES PER WEEK [7]

State	Grade														Total	
	1		2		3		4		5		6		7		8			
	*a	b†	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
California	25	2%	25	2%	25	2%	25	2%	20	1%	20	1%	20	1%	25	2%	185	2%
Massachusetts	60	5%	60	5%	60	5%	60	5%	60	4%	60	4%	120	8%	120	8%	600	7%
New Jersey	‡45	3%	‡45	3%	60	4%	75	5%	75	5%	75	5%	40	3%	40	3%	440	3%
Prussia	135	17%	135	14%	450	39%	495	39%	90	7%	135	10%	180	13%	135	10%	1755	17%

* Minutes per week.
† Percentage of total time.
‡ Nature study and geography combined.

giving much attention to natural science education in the elementary schools, natural science is but one of a list of electives, from which three are selected for teaching in addition to the twelve compulsory subjects of the state curriculum.

A study of German programs and courses of study of individual cities indicates that the natural science material is customarily divided into natural history or biological material (*Naturgeschichte*), and chemistry and physics (*Naturlehre*).

The aims expressed in the Prussian *Richtlinien* are reiterated in all other state courses of study. Instruction in natural science should teach pupils to observe objects, life, and processes in nature in order that they may acquire (1) pleasure in nature, (2) an understanding of nature, (3) ability to apply their knowledge to life situations.

The aims of natural science in the German elementary schools are cultural and utilitarian. They are in no sense vocational; training in the vocations is left to the later period of attendance at the continuation schools. This point of view is in contradistinction to the underlying principle of the American Junior high school and by some German educators is considered a fault of the German system.

The concepts which a pupil obtains from a study of biology in the four upper grades of the elementary school are those relating to the life processes of living things, to the interdependence and interrelations of plants and animals and man, to economic phases of plant and animal life and man's control over living things. In the *Grundschule* particular plants and animals are observed and studied in detail. In the upper grades the study is continuous but broader in that it takes up plant and animal groups and enables the pupil to generalize with regard to large conceptions of Nature.

Natural science has been a required subject in the curriculum of the German elementary schools for many years. The Prussian curriculum of 1872 which was in effect up to the reform in 1920 contained natural science. The significant change in Germany in natural science education is in methods of instruction.

Physics and Chemistry

The same amount of time is devoted ultimately to physical science as to biological science in the elementary schools. A study of the program indicates that both physical science and biological science occur in the four upper grades, but that the greater emphasis in time on physical science comes in the seventh and eighth grades.

Integration of Natural Science Subjects

An examination of courses of study as given previously and observation of instruction in many schools convinces one of a lack of integration among the various branches of natural science. This is a valid criticism of the traditional science of the elementary schools from the American standpoint. The separate subjects of botany, zoology, physiology, physics, chemistry, and mineralogy were taught in the past as separate subjects. The arrangement of these subjects was systematic, with due regard for the interests of the subject, but with little regard for the interests of the pupil. The textbooks were written in the same fashion and gave evidence of no unifying principle.

The old arrangement still persists: botany, zoology, and physiology are commonly taught as biology, but the two subjects of physics and chemistry are still retained as separate subjects in most schools. The courses as such, however, have more favorable content and reform tendencies are at work in Germany to establish an integrated course in natural science in the elementary schools somewhat similar to the general science courses in American schools. The Thuringian Ministry of Education advises that a practical means of advancing an integrated course would be to have the same teacher give all instruction in natural science for each year or, if possible, throughout the four years.

There is convincing evidence from observation that in various schools throughout Germany considerable effort is being made to produce an integrated course. Integration of material within each branch of science around problems of life is a modern step in advance which has been made under the new regime. Integration of instruction of all science into one unified course around certain large units is the step which remains to be made.

Perfect integration of the course around common problems and activities would entail integration within the separate branches of science. Practice always lags behind theory. There is a reluctance to yield the boundaries of the subject matter even in elementary schools. The ordinary teacher in service needs to be educated to this viewpoint.

The method of correlation of subject matter has long been employed in German schools. The history and geography of a region are taught simultaneously with the natural science. By this method the pupil learns more easily, since definite relations can be established. It is also an economy of time for both teacher and pupil. Integration, however, implies a more intimate arrangement of subject matter.

In the upper grades as in the primary grades, the method of natural

science instruction is based on the activity principle. The activity principle demands that the pupil identify himself with a problem, accept it as his own, and solve it, driven on by his own purpose rather than by the will of the teacher. The adoption of the activity method of instruction marks the most significant advance of modern German education in natural science over the old education. The *Richtlinien* indicate that all kinds of activities are to be carried out by the pupil in order that he may learn by doing. In reading through the various courses of study one sees that the instructional walk is one of the most frequent common activities in which pupils engage.

One can scarcely go anywhere in Germany without meeting a class of schoolchildren with a teacher. The excursions may be from a few minutes to several days in duration. Once a month comes the *Wandertag*, or wander-day, prescribed by state law. This can be utilized very well in connection with science study. The region visited is studied as a whole from every possible standpoint. For longer trips, overnight accommodations are provided at very low prices in youth hostels (*Jugendberberge*) and reduced fares are given on the railroads which make longer excursions possible from the financial point of view.

Each child records his experiences in the school and on excursions in a daybook. This is more important than a textbook.

The method of using textbooks in instruction has never been recognized to such an extent in the German schools as in the American schools. Textbooks are used very little except as readers in correlation of science with English. The use of keys, guide books, and maps as aids is more common.

Equipment and Materials for Instruction

In new schools constructed since 1920, laboratory facilities are provided for instruction in physical science. In old schools space in each school is gradually being converted into a laboratory as funds are available. The plans for laboratories vary.

In some cities the science unit consists of two rooms: a lecture hall equipped with tiers of forms for the pupils, a large teacher's demonstration desk, provided with water, gas, and electricity, and a laboratory or activity room, equipped with several tables where the pupils work in groups. Such a room is equipped with supply cases, side shelves at the windows, water, gas, and electricity. Another arrangement is the single activity room equipped with tables and chairs.

Special laboratory facilities for use in biology are rare. As in the *Grundschule* the biology laboratory is the out-of-doors. This cannot be

overemphasized. Practically all the subject matter of the four upper grades, as well as that of the lower grades, is based on instructional walks. This practice of taking the pupil to the natural object is one of the highly commendable features of German education in natural science.

The question of individual *versus* demonstration or group experimentation has never been as vital a problem in German as in American education. The German teacher works for the furtherance of the group. Group work is favored as a means of developing the spirit of community activity, a foundation principle of the activity school as an *Arbeitsgemeinschaft*. In this school, forms of activity which develop the child for service in the community are preferred to the individualistic, selfish forms of activity.

The equipment for science teaching is not as extensive as in the secondary schools, since money is not so available. Compared with American elementary schools, however, the equipment of the average German school is far better. The teachers and pupils make much of the apparatus, such as slides, wooden-ware, and metal-ware.

Organization of Subject Matter and Methods of Instruction

Organization of the content of natural science around large units, with the consequent breaking down of the barriers between the branches of natural science, represents the most modern tendency in curriculum construction in natural science education in the German elementary schools. There is, in addition, the factor of continuity in the German system which, operating from the first grade through the eighth, tends to provide for a unified course. By a synthetic process, begun in the *Grundschule*, in the observation of living things and natural phenomena close at hand the child is gradually supplied with the examples and facts on which to base a few simple scientific conceptions. In the upper grades this instruction continues and a larger number of more difficult conceptions is required.

Several special agencies are important in elementary science work. In most cities one finds a city school museum which contains collections of native plants, animals, and minerals of the vicinity, textbooks and samples of equipment for all subjects of the curriculum, materials for visual instruction, and sometimes a hall which can be utilized by schools not equipped with projection apparatus.

The city school garden exists in large cities. It is a garden maintained by the city, worked by adults, and should not be confused with a school garden in which children work. It supplies plant materials for instruction in biology to such schools as desire this service. Classes can be brought to the garden for field study.

There are excellent scientific museums and planetaria in most cities in which material is set forth in convincing manner. These are utilized by the schools.

In connection with a number of schools are so-called school country homes where a class lives with one or two teachers for two weeks during the school year. From the standpoint of health for city children, of development of community spirit, and of natural science material, the school country home is an important addition to a German city school.

Where schools have connections with a school garden, the children usually work in the garden as a class, for one morning a week. The instruction in garden activities is correlated with science, geography, language and composition, drawing, mathematics, manual training, cooking, in fact with all subjects of the curriculum.

The Training of Teachers

The training of teachers for service in the German elementary school has been placed on a university level. The academic requirements for

Table IV

Total Hours in Natural Science in Secondary Schools of Various States*

School	State						
	Bavaria	Hamburg*	Hesse	Prussia	Saxony*	Thuringia	Württemberg
Oberrealschule	43	47	37	35	39	36	33
Realgymnasium	24	33	29	25	29	26	23
Gymnasium	16	22	21	18	25	18	18
Deutsche Oberschule	†	31	†	34	29	†	†

* Kandel and Alexander. The Reorganization of Education in Prussia. Übersicht über das Austesverfahren sowie den Aufbau und die Ziele der Staatlichen höheren Schulen Hamburgs. Zur Ordnung des höheren Schulwesens, in Sachsen, 1926.

† No data.

entrance to a teachers' college or a pedagogical institute in Germany are the same as those for entering the universities. The student must have the leaving certificate of a secondary school, showing nine years of training beyond the *Grundschule*. The amount of required natural science in these schools varies from a minimum of eighteen to a maximum of forty-eight hours, depending upon the type of secondary school and the state in which the student receives his training. The German idea is, however, that students should receive their academic training before entering the teacher-training institution.

The teachers colleges of Prussia with their two-year course and the school of education at Hamburg with its three-year course may be taken as typical of the two distinct forms of teacher training under the new plan.

As will be seen by a study of Table V the required work in science at the teachers college is strictly professional in nature and bears a close relation to the subject matter to be taught in the elementary school. Gaps in the student's background are supplied by the election of certain science courses as indicated in Table VI.

Observation and participation in elementary schools is provided for. An examination of two parts, written and oral, must be passed before a temporary teaching appointment can be secured. After two years of probationary teaching, during which time the student works with a certain amount of supervision, application may be made for a second examination, after which a permanent appointment will be granted if a position is available.

TABLE V

REQUIRED NATURAL SCIENCE COURSES IN PRUSSIAN TEACHERS COLLEGES[9]

Materials and methods in natural science	1 hr. each week
Animal and plant biology (local)	1 hr. each week
Physiology and anatomy	1 hr. each week
School hygiene	2 hrs. each week
Total	8 hours

TABLE VI

ELECTIVE COURSES IN A PRUSSIAN TEACHERS COLLEGE[10]

Summer Semester, 1927

1. Chemical phenomena of everyday life (inorganic)	1 hr. biweekly
2. Practicum in chemistry for beginners	2 hr. biweekly

Winter Session, 1927–28

Voluntary lectures and practica:

1. Local fields and places	1 hr. biweekly
2. Instruction in heredity and education	1 hr. biweekly
3. Chemical phenomena of everyday life	1 hr. biweekly
4. Practicum in chemistry for advanced students	2 hr. biweekly

In states where the school of education is an integral part of the university, as in Hamburg, Saxony and Thuringia, the training period covers three years. The general plan for the work at Hamburg is given in Table VII. The elective subject indicated may be a science subject, thus allowing for the development of a special field of study for the individual. Students are expected to elect practice dealing with materials and methods of all elementary school subjects. The work in observation and participation

Table VII

General Program for Training of Teachers at University of Hamburg[11]

I. Education, philosophy, psychology—8 hours each semester. (Total, 48 semester hours.)
II. Elective academic or technical subjects, art, corrective pedagogy—8 hours each semester. (Total, 48 semester hours.)
III. Practice, including observation and participation—8 hours each semester. (Total, 48 semester hours.)

of all fields of teaching experience in the elementary school, followed by discussion groups at the school of education, is a valuable feature of this type of German teacher-training.

Training of teachers in service during their probationary years and of older teachers in the newer methods and materials of science is carried on in most states by special institutes.

As a continuous program from the first to the last school year conducted by teachers who themselves have a considerable background of science, with training in the materials and methods of the elementary school, the German program is one which deserves serious attention.

References Cited

[6] Meier, Lois. *Natural Science Education in the German Elementary Schools.* Contributions to Education, No. 445. New York: Bureau of Publications, Teachers College, Columbia University, 1930. p. 49.
[7] Meier, Lois, op. cit. p. 145.
[8] Ibid. p. 118.
[9] Ibid. p. 120.
[10] Ibid. p. 121.
[11] Alexander, Thomas. *The Training of Elementary Teachers in Germany.* p. 129.

The Sequence of Science in the Junior and Senior High School

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The study to be briefly reported is a continuation of two prior papers[1, 2]. The object of this investigation is to attempt to determine the present sequence of science, if any, in the junior and senior high schools.

A number of important problems have arisen partially as a result of the recent extraordinarily rapid development of the junior high school in this country. We can ask ourselves: To what extent has General or Elementary Science gone down into the junior high school? To what extent is the science program of the senior high school integrated with that of the junior high school? What changes, if any, are occurring in the content of these General Science courses? Are there any new science subjects appearing? To what extent is spread or election of science occurring? Is science growing or decreasing in popularity and in numbers of students taking? Are we getting any nearer definite correlation and integration of science subjects and is there more or less overlapping than in former times? All these and many other questions occur to the secondary school teacher interested in science. While it is not possible to answer all of these directly in such a study as this, there is no doubt but that certain trends can be seen and while it is not possible for a questionnaire to give information on all of the subjects mentioned, yet much information can be gleaned from written statements of teachers. Some of this, to be sure, is subjective and simply lists the belief of members of the group, but it is all valuable for those who are interested in the future of science teaching.

In the two previous studies the questionnaire method was used and returns in 1910 were obtained from 276 schools, located in 34 states. In 1923 a larger number of questionnaires elicited results from 368 schools in 44 states. The present study has been supplemented by studies of state reports and field work on the part of the writer. The actual returns from the questionnaire reached a total of 517 schools, of which 206 were junior high schools, 114 were senior high schools of the three-year type, and 197 were the old type four-year high school.

The questionnaire was sent to the original list of high schools used in the two prior studies and to additional schools which were obtained from the

list of high schools printed by the United States Bureau of Education Bulletin No. 26, 1928. The junior high schools were selected largely from various state directories and from lists obtained from individual sources.

The case against the questionnaire has been a severe one. Yet if it is carefully prepared, requesting objective and not subjective evidence, and if the questions are constructed with care, much of the objection to the questionnaire in education is removed. Koos[3] and Kelley[4] and the Research Division of the National Education Association[5] have presented evidence to show that a questionnaire is of undoubted value in certain types of studies. In this study it takes the place of, or supplements, the personal field survey and is undoubtedly of more value than printed curricula and bulletins issued by boards of education. In this study valuable additional information was given by members of the National Association for Research in Science Teaching, to whom I wish to give personal recognition and sincere thanks.

The questionnaire used in this investigation differed in several respects from the one used in the prior studies. It may be that this was a mistake because the information which has been gathered has not taken the exact form given in the first two questionnaires. It was evident, however, that the junior high school had sufficiently established itself in 1930 so that it had begun to play a distinct part in causing a new distribution of science courses. In the questionnaire used in 1923, evidence was given of a very considerable number of general science courses appearing below the ninth year, but in that questionnaire no direct information was sought concerning the junior high school. In the 1930 distribution, however, 500 junior high schools were included.

When we realize that the first junior high schools were established in 1909 and 1910 and when we observe their remarkable growth, the most

Table I

Comparative Number of Courses in Science Offered During Each Year in Four-Year High Schools for the Years 1908, 1923, and 1930

Schools reporting	Number 9th Yr. Courses	Courses per School	Number 10th Yr. Courses	Courses per School	Number 11th Yr Courses	Courses per School	Number 12th Yr. Courses	Courses per School
(1908) 276	360	1.3	319	1.15	334	1.21	360	1.3
(1923) 357	443	1.24	413	1.15	480	1.35	486	1.36
(1930) 310*	479	1.54	462	1.49	459	1.48	420	1.36
(1930) without Hygiene Courses	403	1.3	404	1.3	406	1.31	368	1.18

* 517 schools reporting, of which 113 were three-year and 197 were four-year senior high schools.

conservative are forced to admit that this movement is significant in education. In 1924 Spaulding[6] showed that 77 of 355 towns and cities in Massachusetts had adopted the junior high school idea and that 51 of 68 cities having a population of more than 100,000 were then operating junior high schools. Glass[7] has traced the movement in New York, Pennsylvania and New Jersey and has also showed that the largest development has been in the central west. Today there are nearly 160 junior high schools in California with an enrollment of more than 110,000 pupils. In 1928 there were over 3,500 junior high schools in the United States and today the number has probably reached 5,000. The junior high school curriculum has been planned deliberately with the child as the center and has not evolved slowly as has the senior high school curriculum. Methods and subject matter alike have been adapted to pupils' needs. Experimentation has not only been allowed but encouraged. There has been every reason to include the junior high school in our investigation.

The question most asked among science teachers today is this: "Is science holding its own in the secondary school curriculum?" If we compare the figures obtained from the schools reporting on science courses given for the four years of senior high school (ninth grade to twelfth grade inclusive), as obtained by the 1908 and 1923 questionnaires, with the present status, our first impression is that with a larger number of schools reporting (517) we have a falling off in actual numbers of courses given. But the three sets of figures are not comparable. Although we have answers from 517 schools in the present questionnaire, 206 of these were junior high schools. Table I shows the actual comparative conditions, after omitting the figures from the junior high schools.

One of the outstanding differences between the earlier figures and those of 1930 is in the emphasis placed in health education courses. Prior to the 1923 report the secondary school still held for the teaching of physiology largely as a textbook subject in the early years of the secondary school. Today the emphasis has completely shifted, functional courses in hygiene having taken the place of the anatomy and physiology in the early years. In order to make the figures in Table I comparable, hygiene courses have been omitted. The table is self-explanatory and does not show a very startling growth in the number of science courses at the senior high school level.

Table II shows a percentage comparison of the findings of the 1930 questionnaire as compared with those of 1908 and 1923. In this table "other sciences" include astronomy, geology, psychology, and bacteriology. From this table and from other data obtained in the study, certain definite trends appear which are summed up briefly in the following paragraphs:

(1) Elementary or general science has spread into the seventh- and

TABLE II

PERCENTAGES OF DIFFERENT SCIENCE COURSES OFFERED AT VARIOUS GRADE LEVELS DURING 1908, 1923 AND 1930 AS SHOWN BY RETURNS OF QUESTIONNAIRES

	9th Year			10th Year			11th Year			12th Year		
	1908	1923	1930	1908	1923	1930	1908	1923	1930	1908	1923	1930
General Science	2.5	53.10	66.8		1.93	6.4						
Elementary Biology	10.0	16.09	18.8	7.25	48.13	45.3	2.09	3.47	1.8	1.95	2.67	.28
Botany	21.1	4.37	1.3	29.98	16.22	13.9	7.79	2.5	4.6	8.05	1.85	.85
Zoology	7.5	1.60	.77	26.5	10.41	9.0	7.19	1.87	2.3	4.17	1.44	1.1
Human Physiology	29.17	14.72	3.1	10.72	8.95	2.7	6.29	6.88	4.5	9.01	5.97	6.8
Chemistry				2.52	1.45	6.4	28.14	39.64	48.6	40.55	41.38	28.4
Physics		.43	.26	7.88	2.66	1.5	41.31	40.91	32.0	25.0	39.30	49.1
Physiography	26.11	10.11	3.1	15.46	9.92	6.4	1.81	4.18	3.1	4.72	6.17	2.3
Other Sciences	3.61	.43				1.3	2.39	.41	1.1	6.38	1.44	2.86
Advanced Biology						4.4			2.0			3.1
Agriculture			5.9			7.4			5.1			3.4

eighth-grade levels, while the top of the curve for general science still appears in the ninth grade, a very considerable number of courses are given in the seventh and eighth grades. Many school systems, especially in larger cities, have definitely worked out a three-year sequence of science for the seventh, eighth, and ninth grades in the junior high school. In such sequences we usually find the seventh grade giving from two to four periods a week, the eighth grade receiving about the same number of hours, while in the ninth grade the median appears to be five hours a week.

(2) A second noticeable feature is that hygiene as such is appearing not only in the junior high school but to a much larger extent in the senior high school than in former times. While it is possible that the difference in the wording of the questionnaire may have brought out this fact, yet it is also true that hygiene as such has had a phenomenal growth in this country during the past decade. The emphasis on health education is making its way from the elementary school up into the junior high school and into the senior high school. In many school systems distinct emphasis is being placed on the teaching of health habits at the seventh-grade level.

Studies of general science textbooks by Miss Meier[8] and of elementary biology texts by Chappelear[9] show that in the general science texts up to 35 per cent of the subject matter may be devoted to health education material, while in the elementary biology texts as high as 57 per cent of the material may be of a health education nature.

It is also possible that the questionnaire does not actually show the true situation with reference to hygiene courses since the consensus of opinion among teachers is that health teaching should be indirect rather than direct. A question asking whether hygiene was given as a separate subject or whether the tendency is to make health instruction a part of the work of several departments, brought out the information that, in over 44 per cent of the schools reporting, health education material is a part of the work of the teachers of physical education, general science, biology and even English, history and civics, as it undoubtedly should be.[10]

(3) A third evident finding is that although general science has spread downward into the seventh and eighth grades, it still holds a very distinct place in the ninth grade. If we peruse courses of study and recent curricula we find that the general science in this grade, is changing in its curricular material, for instead of the emphasis being placed on the earth science or physical sciences, the tendency now seems to be to emphasize the biological aspect, especially as that phase affects the conservation of health and wealth.

(4) Another finding is that general biology is still firmly ensconced in the tenth grade. Although there appears to be a distinct tendency toward a movement downward in certain states, perhaps it would be more correct to

say that this tendency is a spread in both directions, as there are appearing courses in advanced biology which in New York State are localizing in the tenth year with options for students in the eleventh and twelfth years. In other states, notably California, advanced biology is appearing in the twelfth year, but with scattered courses in the eleventh as well. Many school systems are opening up their courses in biology to students in the tenth, eleventh, and twelfth grades.

In New York State, as a study of statistics given by the State Department of Education indicates, a very considerable number of students take advanced biology in the tenth year. It must be remembered that New York State is out of step in the general sequence as found in other parts of the country and a readjustment will evidently place general science in the ninth year and biology in the tenth year, thus bringing the state in line with the general trend over the country.

(5) The situation with reference to the chemistry-physics sequence is still unsettled, some states preferring chemistry in the eleventh year followed by physics, and other states preferring just the opposite sequence. In Pennsylvania, Michigan, Indiana, Massachusetts, Ohio, California, Wisconsin, Washington and Oregon, there is a distinct tendency toward chemistry in the eleventh and physics in the twelfth year. In Connecticut, New Jersey, New York, Illinois, Iowa, Missouri, Colorado and Montana there seems to be fairly well established the reverse sequence of physics in the eleventh and chemistry in the twelfth year. In the case of California, for example, the tabulation of information from the eight four-year schools and the nine three-year schools answering the questionnaire showed that of 17 courses in physics and chemistry reported, 11 chemistry and 11 physics were open to eleventh and twelfth year pupils. This would seemingly make the sequence doubtful. But personal visits to schools, or reports from persons who had contact with these and other schools, brought out the fact that in 65 senior high schools (all but six being four-year schools) 63 placed chemistry in the eleventh year and 60 placed physics in the twelfth year. In these same schools general science was offered by 54 in the ninth year and biology by 55 in the tenth year. A study by Roy Knapp, presented for the degree of M.A. in the Claremont colleges in 1931, will show for California that 82.67 per cent of all general science courses are in the ninth grade; 66.87 per cent of all biology courses are in the tenth grade with about 16 per cent in the eleventh or twelfth year; 45.81 per cent of the chemistry courses are in the eleventh year, with 48.6 per cent in the eleventh and twelfth; 55.5 per cent of the physics courses are in the twelfth year with 37.5 per cent in the eleventh and twelfth. Only 5.6 per cent of the chemistry courses are in the twelfth year only, and only 7 per cent of the physics courses are in the elev-

enth year only. Such findings give evidence of a definite sequence of science in this state.

A careful study of Table III and Figure 1 compiled from the field study, shows one rather significant trend in the chemistry-physics sequence. Since the publication of the 1923 study there has been a distinct gain of 9 per cent in chemistry courses in the eleventh year with a corresponding loss of 9 per cent of physics courses in that year. In the twelfth year physics shows a gain of 10 per cent in courses while chemistry shows a loss of about 13 per cent in the same year. In the suggested state sequences there are twelve states giving the chemistry-physics sequence while only three states recommend the physics-chemistry sequence for the last two years. All this seems to indicate a trend to place chemistry before physics in the sequence in the four-year high school and in the three-year high school.

TABLE III

NUMBERS AND PERCENTAGES OF SCIENCE COURSES OFFERED ON EACH GRADE LEVEL IN 517 JUNIOR AND SENIOR HIGH SCHOOLS

Grades	Gen. (Elem.) Science		Elem. Biology		Chemistry		Physics	
	Courses	%	Courses	%	Courses	%	Courses	%
7	90	17.4	1	.38				
8	164	31.7	2	.77				
9	259	50.1	73	28.00			1	.30
10	4	.77	176	67.60	25	8.3	6	1.97
11			7	2.70	170	58.0	125	41.00
12			1	.38	100	33.8	173	56.70

Table III shows not only the preponderance of general science courses but also the fact that such courses are found in greatest numbers in the ninth year. Elementary biology has apparently lost ground slightly by comparison with 1923. But with the growth of advanced biology and the inclusion of an increasing amount of biological subject matter in general science it is likely that more pupils are receiving a general biological background than in 1923. The larger number of physics courses as compared with chemistry probably means that for college entrance purposes physics is still the choice and that pressure brought to bear on the smaller schools give these results.

A perusal of the returns on that part of the questionnaire which called for the number of students enrolled in courses indicates that in spite of fewer courses in chemistry the number taking this subject in the larger schools far exceeds the number taking physics while the numbers taking the two subjects in the smaller schools are more nearly equal.

(6) Another significant finding is the tendency toward dropping out of the special sciences. There has been a noticeable decrease in botany and zo-

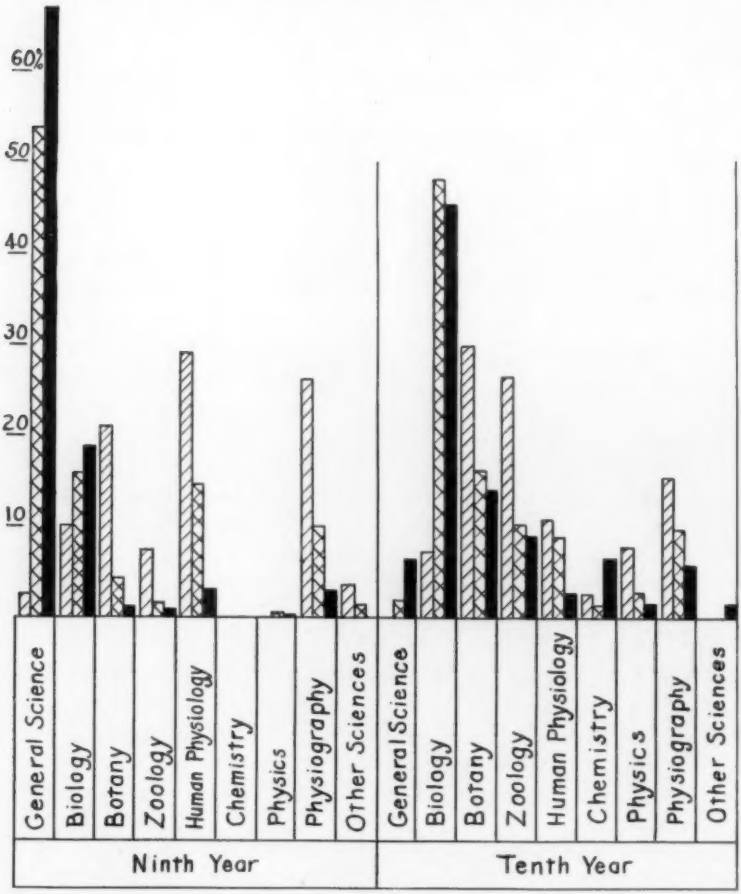

FIGURE 1. Percentages of Science Offerings in the Four-Year High Schools Based on Findings of Questionnaires for 1908 (single-hatched bars), 1923 (cross-hatched bars), and 1930 (solid bars).

ology since the publication of the last questionnaire in 1923. A glance at the table shows a very significant falling off in physiography courses, this subject losing proportionately more than any other of the special sciences.

It is probable that the figures on agriculture are not very complete. Many schools supported by the Smith-Hughes Act funds give courses in agriculture which play a significant part in the science activities of the schools. Particu-

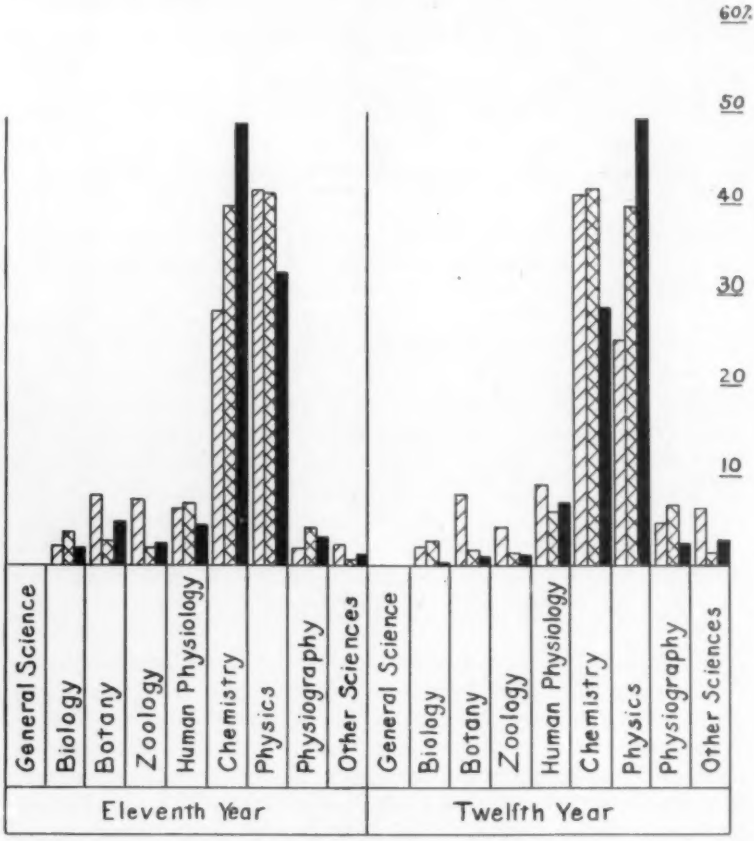

FIGURE 1 (Continued from page ???)

larly is this true in the land-grant college states. The figures given for 1930 do not necessarily mean an increase of courses over 1925, as this subject was not specifically called for in the 1923 questionnaire.

(7) Human physiology, too, has shown a distinct decrease except in the twelfth year. In some states there is a distinct tendency toward making hu-

man physiology a laboratory science given in the last year of the senior high school after a certain amount of chemistry or physics. Hygiene has supplanted human physiology, especially in the lower years of senior high school as we may see by reference to Table I. A glance at the Figure 1 sums up the findings in a definite manner.

A comparison in the senior high school of the numbers taking general science and biology indicates a great preponderance of general science pupils in the ninth year. Probably at least twice as many pupils are taking biology

Table IV

Public School Enrollment (1929–1930) State of New York
Physics, Chemistry, Applied Chemistry, Advanced Biology, Physical Geography, General Science, Biology

	Number of Pupils					Number of Schools				
	By Grades				Total*	By Grades				Total†
	9th	10th	11th	12th		9th	10th	11th	12th	
Gen. Sci.	32860	2937	300	101	36513	224	119	57	24	232
Elem. Biol.	71187	7047	1320	791	92736	751	396	134	80	790
Physics	1057	1540	17282	8990	29656	13	246	607	609	670
Chemistry	420	9811	8162	10365	30127	13	155	395	441	455
Applied Chem.	86	1887	480	284	2738	4	15	22	24	29
Adv. Biology	351	10330	4193	2822	18807	11	42	39	35	54
Phys. Geography (Physiography)	148	1594	3469	3587	9180	31	136	192	188	215

* Totals include pupils for whom no distribution by grades is given.
† Totals include schools for which no distribution by schools is given.

in the tenth year as are taking chemistry or physics in the eleventh and twelfth years. An unpublished thesis by Knapp shows clearly the trends given above for the state of California. Here biology has grown considerably in enrollment during the past 15 years; chemistry, with an enrollment less than biology, is just about holding its own; physics is losing quite rapidly in enrollment. Phillips[11] in his statistics of public high schools reports in 1927-28: 7,686 schools give biology to 183,151 boys and 210,240 girls, a total of 393,391; general science is taught in 9,845 schools to 356,866 boys and 250,172 girls, a total of 507,038. These figures bear out the returns obtained from the questionnaire. But his figures for physics and chemistry are higher than would appear to be given in this study. He states that 4,783 schools are giving chemistry with an enrollment of 118,641 boys and 86,053 girls or a total of 204,694 while 7,346 schools give physics courses to 180,209 boys and 68,193 girls or a total of 248,402. If we include the general science

enrollment in the junior high school, then the figures have another story to tell. Here, although our figures are not accurate, it is evident that there is an enrollment of several times that of the biology of the senior high school. In many junior high schools science is a required subject in at least one year and often two years, hence the great increase in the number of students taking the course.

Enrollment in the special sciences is relatively small, botany, human physiology, physiography, zoology, astronomy and geology apparently ranking in the order given. Two new sciences appear, namely, bacteriology and psychology, but the offerings are few and the number of students enrolled is very small.

Some interesting figures, obtained through the courtesy of Warren W. Knox, Supervisor of Science for the University of the State of New York, are worth giving at this time to show the situation as it exists in a state having the largest high school enrollment in the Union.

Aside from the fact that these figures show science to be in a healthy condition, an interesting situation is found here which is sustained by the returns to the questionnaire from other states. This is the spread of science courses over different grade levels in the senior high school. While in the junior high school the offerings in science are restricted to pupils in a given year, it is true that increasingly there is a spread in the election of science courses. Many courses in chemistry and physics are open to pupils in the eleventh and twelfth years in botany, zoology, physiology, and to a less extent elementary and advanced biology are offered to pupils of the tenth, eleventh and twelfth years. The reason for this is not entirely clear. It may mean (and probably does mean) that because of an overcrowded curriculum, science is offered where it will fit into the pupil's program. It may mean a desire and perhaps a pressure to persuade more pupils to take science or it may mean a real interest in science offerings on the part of the pupils and the administration.

In spite of this spread over the several years of the senior high school, there is much evidence that the sequence of science is fairly definite. A personal survey of nation-wide conditions based on courses of study and visits to important schools in different states was made as a check against the results of the questionnaire. Table V shows a summary of this study.

Three significant outcomes stand out in a comparison with the figures from the questionnaire: first, definite sequences in science exist, at least on paper, in several states; second, there is no agreement among supervisors as well as among teachers as to the proper sequence of high school chemistry and physics; third, in some cases, state courses of study as they exist on paper are not in accord with the evidence sent in by teachers who answered the

TABLE V

SCIENCE SEQUENCE BASED ON STATE COURSES OF STUDY

Grade:	7th year	8th year	9th year	10th year	11th year	12th year	Agreement with Questionnaire
New England States							
Connecticut			Gen. Sci.	Biol.	Chem. or Physics	Chem. or Physics	No
Maryland			Gen. Sci.	Biol.	Chem. or Physics	Physics or Chem.	Yes
New York*	Gen. Sci.	Gen. Sci.	Gen. Sci., Biol.	Biol. (Adv.)	Physics or Chem.	Chem. or Physics	Yes
New Jersey	Physiog. & Hygiene	Physiog. & Hygiene	Gen. Sci.	Biol.	Chem.	Physics	No
Pennsylvania	Geog. & Sci.	Geog. & Sci.	Gen. Sci.	Biol.	Physics	Chem.	No
Southern States							
Alabama	Gen. Sci.	Gen. Sci.		Biol.	Physics	Chem.	50–50
Kentucky			Gen. Sci.	Biol.	Chem.	Physics	50–50
Louisiana (7–4)		Gen. Sci.	Biol.	Chem., Physics	Chem., Physics		No.
Mississippi			Gen. Sci.	Biol.	Chem.	Physics	Yes
N. Carolina (7–4)		Gen. Sci.	Biol.	Chem.	Physics		Yes
Tennessee			Gen. Sci.	Biol.	Chem.	Physics	No figures
Texas			Gen. Sci.	Biol.	Chem.	Physics	Yes
Virginia (7–4)		Gen. Sci.	Biol.	Chem.	Physics		Yes
W. Virginia	Elem. Sci.	Elem. Sci.	Gen. Sci.	Biol.	Chem.	Physics	No figures
N. Central States							
Illinois			Physiog., Hygiene Gen. Sci.	Biol., Bot., Zool.	Physics, Chem.	Physics, Chem.	No
Indiana		Gen. Sci.	Biol., Gen. Sci.	Biol., Bot., Zool.	Bot., Physics, Zool., Chem., Physics	Physics, Chem., Physiol.	Yes
Iowa	Elem. Sci.	Elem. Sci.	Agric., Biol.	Bot., Biol.	Chem., Physics	Chem., Physics	No
Michigan	Elem. Sci.	Elem. Sci.	Gen. Sci., Biol.	Biol., Bot., Adv. Biol.	Chem., Physics, Adv. Biol.	Chem., Physics, Adv. Biol.	Yes
Rocky Mountain							
Arkansas	Gen. Sci.	Gen. Sci.	Gen. Sci.	Biology	Chem.	Physics	No
N. Dakota	Agric., Hygiene	Elem. Sci., Hygiene	Elem. Biol.	Physiog., Adv. Biol.	Chem., Physics, Adv. Biol.	Chem., Physics	Yes
S. Dakota	Agric., Hygiene	Elem. Sci., Hygiene	Elem. Biol.	Physiog., Adv. Biol.	Chem., Physics, Adv. Biol.	Chem., Physics	Yes
Pacific States							
California	Gen. Sci.	Gen. Sci.	Gen. Sci.	Biology	Chem.	Physics, Adv. Biol.	Yes
	7	8	9	10	11	12	
SUMMARY	9 Elem. Sci. 4 Hygiene 2 Agric. 1 Geog. & Sci.	15 Elem. Sci. 5 Hygiene 1 Geog. & Sci.	18 Gen. Sci. 7 Elem. Biol. 1 Physiog.–Hygiene 1 Agric. 1 Bot. 1 Physiol.	20 Biol. 2 Adv. Biol. 4 Bot. 2 Zool. 2 Physiog. 1 Physiol. 3 Chem (7–4) 1 Physics (7–4)	19 Chem. 12 Physics 3 Adv. Biol. 1 Bot. 1 Zool. 1 Physiol.	20 Physics 13 Chem. 1 Physiol. 2 Adv. Biol.	
12 states with clear preferred sequence	Elem. Sci.	Elem. Sci.	Gen. Sci.	Biol.	Chem.	Physics	
3 states	Elem. Sci.	Elem. Sci.	Gen. Sci.	Biol.	Physics	Chem.	
1 state			Gen. Sci.	Biol.	Chem.-Physics	Physics-Chem.	
1 state			Gen. Sci.	Biol.	Physics, Chem.	Chem.-Physics	
6 states			Gen. Sci.	Biol.	Chem., Physics	Chem.-Physics	

questionnaire. Either we must doubt the evidence taken from a sampling of the better schools or we must believe that teachers do not always follow courses of study as outlined by those in authority. Since the answers from the questionnaire come from a picked group of teachers it may represent the practices of a small but advanced group of thinkers. The writer does not attempt to answer this question but gives the figures for what they are worth.

Obviously only a small part of the findings of the questionnaire can be discussed at this time, the question of science sequence being the problem in hand. It is evident from the findings that the sequence already established is gaining ground with evidence that points to (a) a greater spread downward of elementary or general science, (b) a possible spread of biological material both upward and downward through the intermediary of advanced biology and the placement of more biological subject matter in general science, (c) possibly (if this sampling of schools tells the story) a more definite placement of chemistry in the eleventh year and physics in the twelfth, and (d) a continued reduction in the number of courses and of pupils taking the special sciences. It might almost seem that the dream of the teacher who teaches *children* and not special science might some day be realized so that we will see a continuous course in science throughout the junior and senior high schools, built not on special science subject matter, but arranged psychologically on the rational basis of children's interests and adult life needs. With the greater use of psychological tests on the part of the college, the bugbear of the college entrance examination and the evils of the unit entrance system may be done away with. Then, and then only, will science be able to measure its results scientifically and give to the pupil the materials and training best adapted to his individual needs.

Physics-Chem. Chem.-Physics Chem.-Physics
Chem.-Physics Physics, Chem. Chem., Physics
Biol. Biol. Biol.
Gen. Sci. Gen. Sci. Gen. Sci.
1 state 1 state 6 states

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Science Reading Material for Pupils and Teachers—II*

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Serviss—*Astronomy With the Naked Eye.* Harper and Brothers. $3.00. 1908.
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Bliss—*Elements of Applied Electricity*. Henry Holt and Co. $1.96. 1925.
Bragg—*Concerning the Nature of Things*. Harper and Brothers. $3.00. 1925.
Buckley—*A Short History of Physics*. D. Van Nostrand and Co. $3.00. 1928.
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COWDRY, et al—*Human Biology and Racial Welfare*. B. Hoeber. $6.00. 1930.

CURTIS—*Science and Human Affairs*. Harcourt, Brace and Co. $3.00. 1922.

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Soddy—*Science and Life*. E. P. Dutton and Co. $4.00. 1920.

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Sullivan—*The Bases of Modern Science*. Doubleday, Doran Co. $2.00. 1929.

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Thomson—*Modern Science*. G. P. Putnam's Sons. $3.50. 1929.

Whitehurst—*Science and the Modern World*. The Macmillan Co. $2.50. 1925.

WILSON—*The Human Side of Science*. Metropolitan Book Corporation. $4.00. 1929.

WISEHART—*Marvels of Science*. The Century Co. $2.50. 1928.

Symposium—*Living Philosophies*. Simon and Schuster. $2.50. 1931.

Symposium—*Popular Research Narratives*. (3 Volumes.) Williams and Wilkins. $3.00. 1926.

PART III. COLLEGE TEXTBOOKS

A. Astronomy

DUNCAN—*Astronomy*. Harper and Brothers. $3.75. 1926.

FATH—*Elements of Astronomy*. McGraw-Hill Book Co. $3.00. 1926.

MOULTON—*Astronomy*. The Macmillan Co. $3.75. 1931.

RUSSELL, DUGAN and STEWART—*Astronomy* (Volume I): *The Solar System*. Ginn and Co. $2.48. 1926.

RUSSELL, DUGAN and STEWART—*Astronomy* (Volume II): *Astrophysics and Stellar Astronomy*. Ginn and Co. $2.48. 1927.

B. Biology

ATWOOD and HEISS—*Educational Biology*. P. Blakiston's Son and Co. $2.75. 1928.

BURLINGAME, et al—*General Biology*. Henry Holt and Co. $3.50. 1922.

CALDWELL, SKINNER and TIETZ—*Biological Foundations of Education*. Ginn and Co. $2.72. 1931.

EIKENBERRY and WALDRON—*Educational Biology*. Ginn and Co. $2.48. 1930.

GAGER—*General Botany*. P. Blakiston's Son and Co. $4.00. 1926.

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PLUNKETT—*Outlines of Modern Biology*. Henry Holt and Co. $3.75. 1930.

SHULL—*Principles of Animal Biology*. McGraw-Hill Book Co. $3.50. 1929.

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GORDON—*Introductory College Chemistry*. World Book Co. $3.60. 1930.

KENDALL-SMITH—*General Chemistry*. The Century Co. $3.75. 1929.

MCPHERSON and HENDERSON—*A Course in General Chemistry*. Ginn and Co. $3.40. 1927.

HOLMES—*General Chemistry*. The Macmillan Co. $3.50. 1931.

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Pack and Palmer—*The Nature Almanac*. Nature Study Association. $1.00. 1930.

Vinal—*Nature Guiding*. Comstock Publishing Co. $3.50. 1926.

E. Geology

Bradley—*Earth and Its History*. Ginn and Co. $2.60. 1928.

Daly—*Our Mobile Earth*. Chas. Scribner's Sons. $5.00. 1926.

Hobbs—*Earth Features and Their Meanings*. The Macmillan Co. $4.25. 1912.

Pirsson and Longwell—*Outlines of Physical Geology*. John Wiley and Sons. $3.00. 1930.

Salisbury—*Physiography*. Henry Holt and Co. $3.80. 1919.

Schuchert—*Outlines of Historical Geology*. John Wiley and Sons. $3.00. 1931.

Shimer—*Introduction to Earth History*. Ginn and Co. $3.00. 1925.

Tarr and Von Engeln—*Physical Geography*. The Macmillan Co. $2.40. 1929.

F. Physics

Caswell—*An Outline of Physics*. The Macmillan Co. $4.25. 1928.

Kimball—*College Physics*. Henry Holt and Co. $3.75. 1929.

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Osborn—*Physics of the Home*.—McGraw-Hill Book Co. $3.00. 1929.

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Does a Teacher Need to Know Biology?

ELIZABETH L. BISHOP
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What biological background, if any, is essential or desirable for the classroom teacher? The child at the receiving end of the educative process is a biological creature. Every well-brought up teacher knows that the *child* and not the subject is the center of all her teaching activities. What does she know (if anything) or need to know about his structure and functioning, and the interplay of biological forces in his development and behavior? Or if you belong to the school of the newer pedagogical prophets, and cringe at the thought of the child as the passive recipient of a process, preferring to see him as a personality at whose development the teacher merely assists in the rôle of guide, philosopher and friend—still what does she know or need to know about the biological entity whose developing individuality she is earnestly striving to help unfold? It seems axiomatic that an artist should understand thoroughly the medium in which she works. Are we perhaps assuming, without much investigation into the facts, that the teacher-artist comes from her training as well-equipped with insights and skills concerning children as she is, say, in the mechanics of lesson plans and the skills incident to the routine of school house-keeping?

A little illumination is thrown upon this matter by some facts which emerged incidentally in a study recently made in a California university. Any deductions made from these facts can, of course, be valid only for the individual institution concerned. How far the same situation is prevalent elsewhere is as yet unknown. It should be borne in mind that the requirements for teaching credentials in California are relatively high, and the probabilities are strong that her teachers are not less well-grounded in biological science than those of other parts of the country.

The study in question concerned the selection of desirable content for the course in "Growth and Development of Children," which is so "strongly recommended" in preparation for several of the California teaching credentials that it is practically a requirement, and appears in all teacher-training curricula. In the course of the study, it became necessary to get a picture of that section of the student body represented from year to year in the course enrollment, together with some idea of what might be expected from the average student in the course, in the way of background training in education, psychology, and biological sciences. For this purpose, a simple questionnaire was prepared and data were collected during class meetings,

from approximately six hundred students in the fall semester, and three hundred in the spring semester, a sufficiently large number to yield a reasonable picture of the type of student to be expected in future classes in regular session. Analysis of these figures showed the fall-spring classes to include a very few junior students, but a majority of senior and fifth year people, preparing directly for the elementary or the secondary teaching credential. During summer session, the same data were collected from approximately two

Table I

Biological Background of Students Taking "Growth of the Child" in a California University

Amount of Biological Science Student has had	Per cent of Class Reporting It			
	Fall Semester	Spring Semester	Academic Year	Summer Session
No biological science in high school*	58.0	55.0	57.0	25.0
No biological science in college	33.0	34.0	33.6	14.1
No biological science in high school or college	22.0	21.0	21.7	9.6
No biological science nor hygiene in either high school or college	11.8	13.3	12.5	8.8
One course† biological science or hygiene in high school or college	22.6	23.6	23.0	9.6
Two courses in biological science (including hygiene) in high school or college	22.0	27.0	24.0	14.5
Three courses	13.5	16.0	14.5	20.2
Four or five courses	15.5	10.0	13.2	29.5
Six to twenty courses	14.5	10.6	12.8	17.4

* The sciences most favorably received by the California universities for college entrance are physics and chemistry.

† A "course" was counted for one year of high school science or for one semester of college science.

hundred and fifty people, chiefly teachers and administrators, who were representative of the run-of-the-mine summer student in the education department. Most of these people were working toward higher degrees or credentials. There were a few senior university students and a few normal school and teachers college graduates. No one had less than two years of collegiate work; two-thirds of the group were graduates of four-year colleges and universities; and over ten per cent had master's degrees.

The teaching experience in the summer group varied from one to thirty years, spread over the educational ladder from pre-school to college, and geographically over twenty states and a foreign country. The majority were then teaching, or hoping to teach, in California. The list of major fields of study represented reads like a roster of the university curricula.

A check of the questionnaires showed that practically all students enrolled in the course had completed one or more courses in elementary education or secondary education, over ninety-five per cent of the fall-spring students and seven out of ten of the summer students had "taken" both psychology and educational psychology. These courses are standard requirements for California teaching credentials, and are commonly held pre-requisite to the course in "Growth and Development of Children." The range and variety of courses in biological science was so wide as to challenge any attempt at classification. A preliminary check showed that if hygiene were included, all but twelve per cent of the total enrollment had had some exposure to biological science, either in high school or college. More careful study revealed the situation which is outlined in Table I.

The summer group, being somewhat further advanced in their training, showed better biological background, in terms of courses taken, than the groups of the regular session. In all the groups, the biological preparation varied from absolute zero to completed majors in biological fields, but the large majority of the students had taken two or more courses of a biological nature at some time in their career.

With the general background in education and psychology possessed in common by the students in these classes, and with their biological background, heterogeneous as it was, they might reasonably be expected to have more or less clear concepts of the meanings of essential terms in common use in the copious literature of education, psychology, and child development, including those terms derived from the fields of the biological sciences. That they did not possess such a working vocabulary and were probably reading much professional literature, whose terminology was incomprehensible to them, was suggested to the instructors by some amazing misinterpretations of biological and physiological terms reported by a reader in the course. It was decided to examine written work done in ordinary class routine for evidences of familiarity or lack of familiarity with commonly used terms. No attempt was made to set up an experimental situation.

The first papers used were regular examination papers written by the summer school class and containing a dozen or more definitions of biological terms commonly found in the literature of child development, and which, it had been assumed, should be familiar to upper division and graduate university students and to well-educated teachers of experience. Such a wide range of misinformation was evidenced in these papers written by mature and experienced teachers and administrators, and the general relationship between meagre vocabulary and lack of success in the course was so marked, that it was thought worth while to give the same paper as a kind of pre-test at the beginning of the fall semester for the purpose of tentative

sectioning into ability groups. The papers were scored independently by the regular reader in the course, on criteria set up by the instructor, and by the present investigator. Definitions on which the two judges disagreed were discarded and not included in the score. The scoring was, of necessity, somewhat subjective, owing to the nature of the material. The definition was scored positively if the student showed any indication of grasping the nature of the term and negatively only when the definition was wide of the mark or omitted entirely. A representative sample* of one hundred papers was studied for each class group. The results of the check might very well be entitled—"What the Well-Educated Teacher Does Not Know."

The words for which definition or explanation was asked were: metabolism, chromosomes, genes, thorax, diaphragm, abdomen, endocrines, foetus, cretin, behaviorism, and heredity. Of these words, the only ones known well enough to be defined intelligently by more than a quarter of the sample group were *heredity* and *foetus*, and the latter word was wholly unfamiliar to over half of the fall-class sample. More than half of all the students were unfamiliar with *metabolism, chromosomes, genes, endocrines, cretin,* and *behaviorism*. Everyday words such as *thorax* and *abdomen* had no exact connotation for one-third to one-half of the group. The particular types of ignorance evidenced are best shown by some abstracts from the papers. Some of the definitions which caused gleeful chortles from the reader have had to be deleted here in consideration of the fact that publishers and postal authorities have their reticences. One might say in passing that it appears that the younger generation apparently is less well informed on the "facts of life" than they like to have us believe. Selecting discreetly from the wealth of material at hand, we find that:

> The *thorax* is a gland in the throat; an organ in the chest region; a disease of the throat; a tube in the throat leading to the lungs; a breathing organ in the chest in front of the œsophagus; the front region of the body including the abdomen; a bone in the chest; the upper portion of the spinal column; a bone in the region of the hip affecting child-bearing. The *abdomen* is a part of the stomach; a muscle in the lower stomach; the organ in which digestion is carried on. The *diaphragm* is a place where one should breathe from; a small organ used in breathing; a part of the body containing the heart and lungs and opening into a fan shape when singing; a boney area compressing the area around the ribs; a bone dividing the upper part of the body from the lower; a part of the alimentary canal; a strong tissue covering the intestines; the bones or ribs which surround the chest.
>
> *Endocrines* were quite commonly recognized as glands, but were variously located in the throat, kidneys, intestines, stomach, brain and in the "abdomenal" region. They were said to influence digestion, child-bearing, and sexual behavior. They were further identified with sweat glands, stomach juices, and nerve endings.
>
> *Metabolism* is a breakdown in bodily health; activity of the body in throwing off disease germs; process having to do with the purification of the blood; dividing

* The method of sampling this diverse group is added as an appendix.

of sex cells; the process by which the skin adapts itself to the surrounding atmosphere; the process of starch becoming sugar in the mouth; functioning of the nervous system; something absolutely necessary for the existence of life; breaking down the blood cells; a respiratory process.

Chromosomes are color cells; a red substance in the ovum; particles in the blood which contain hereditary characters and determine sex; cells in the body which must be "effected" if there is hereditary weakness. *Genes* are ancestors; species; germ cells; reproductive organs; substance in the blood stream; beginnings of a new birth; Man.

A *cretin* is a substance in the blood; a sticky substance; a hard substance something like lime; a glandular excretion; a form of feeblemindedness found in children due to birth injury; inhabitants of the Isle of Crete; a child whose parents had venereal disease. A *foetus* is reported to be a gland; an offspring; a discharged residue; waste material; a substance which later develops into a cell; a place of fertilization.

Behaviorism was missed by approximately eighty per cent of the class, a fact of some interest because more than nine out of ten of the students reported exposure to at least two psychology courses. Such definitions were found as:

a manner of actions resulting from volition; a method of judging people without holding them responsible for their actions; why humans behave as they do; the philosophy by which a human acts in response to instincts and cannot help himself; a theory sponsored by Watson which lays stress upon the unconscious; the actions of a naughty child; sexual behavior; the actions or habits of behaving or being good; traits of young children; how one substance behaves toward another.

That the vocabulary situation shown in this cursory examination of a limited group of students is not peculiar to them alone, seems probable. Twenty-five papers picked at random from a pile of two hundred written by still another section in the course, yielded in a few moments the following descriptions of physiological terms which had occurred in class lectures and class reading:

The *eustachian tube* transmits sounds from the outer ear or collector, to the inner ear, or receiver: it is the tube leading from the ear to the nose, which regulates the balance of the body; that part of the ear which pertains to the sense of balance; connects outer and inner ear, and has at its inner end the tympanum or ear drum; connects the ear with the nose, eye and throat; the connecting link between mother and embryo. *Adrenal* is that flow of spleen that comes over a person when he has the emotion of anger. *Hormones* are determiners of what inherited characteristics will be; unicellular bodies carrying nerve impulses in the blood stream from glands to organs; sex determining cells; a part of the germ cell causing traits in an individual. The *thymus* is the long part of the cerebrum located near the top of the brain and has to do with coordination; thymus is the name for muscle tone.

The revelations from this study suggested a further investigation into the kinds of biological science courses which had been selected by (or for)

these prospective teachers during their college preparation for teaching. The figures in Table II furnish some food for reflection in this matter. In planning a curriculum leading toward a teaching credential at any level of the educational ladder, it would seem advisable to include biological materials and techniques which would contribute toward insight into the complex matter of the growth, development, and behavior of children, and which would provide an adequate general biological vocabulary to make the current literature in child study intelligible to the classroom teacher. It is not too much to expect a teacher to be able to distinguish a youngster's thorax from his thyroid, and his hormones from his chromosomes.

TABLE II

PERCENTAGES OF THE MAIN TYPES OF BIOLOGICAL COURSES REPORTED BY THE STUDENTS TAKING "GROWTH OF THE CHILD" IN A CALIFORNIA UNIVERSITY

Biological Preparation Included	Fall Class	Spring Class	Academic Year	Summer Class
College Zoology	42	44	42.5	37.1
College Botany	16.5	18.0	17.5	31.1
College Biology	11.0	10.0	10.3	28.6
College Physiology	16.0	10.0	13.5	33.5

It will be noted in Table II that in the institution in question, zoölogy is the leading biological science reported, with botany a not very close second. Biology and physiology make relatively poor showings, particularly with the undergraduates. This predominance of zoölogy is not true of the curricula in many of the teachers' colleges in California, not a few of which are now including physiology or biology among the foundation courses in teacher-training curricula. It may not be the situation elsewhere in the country. However, in this institution, zoölogy is the main biological science taken by teachers in training, and judging by the findings here reported, it does not prove to be an adequate foundation for the study of living children.

The argument immediately arises that the purpose of these courses in zoölogy and botany is not teacher-preparing, except as taken by students preparing directly to teach zoölogy and botany in secondary schools, but that they are essentially background and cultural courses, giving necessary breadth and depth to the student's general information. Without decrying the very real virtues of zoölogy or botany as a part of the cultural assets of a teacher, it is suggested that in planning the science aspects of a curriculum for the potential teacher of any kind, there should be included

some consideration of general biological principles applicable to all living things, and some contact with the structure and functioning of humans, as well as of conifers and sharks. As a teaching major, either biology or physiology is a better choice than either zoölogy or botany, neither of which occurs with any frequency in the curricula of the secondary schools of California.[1] Biology as a teaching major is a particularly good choice, since it is one of the "big four" sciences taught in the high schools of California and elsewhere.[1] Physiology given in the junior or senior year of high school has recently been included in the sciences accepted by the University of California at entrance; hence a need arises for more physiology teachers, whom the universities will need to prepare.

Not all teachers will teach biological sciences, but every teacher will deal with that biological phenomenon, the child, and the evidence is adequate to indicate that in many cases they are dealing with biological material concerning whose structure and functioning they have very sketchy or entirely erroneous notions. Such a situation is full of dynamite, as many a teacher has found to her cost—or the child's cost. The plea of this paper is for adequate general training in biological facts and principles, for every novice-teacher in every teacher-preparing institution in the country.

APPENDIX

Technique Used in Selecting a Representative Sample from a Large Class Group with a Wide Variation in Training

The problem of getting a random but representative sample from a group of students with such diverse preparation as occurred in the classes used in this study, was sufficiently puzzling to warrant reporting the method which was finally worked out for sampling these groups.

The summer group presented no particular problem in sampling. For another aspect of the study of the course, approximately one hundred high school teachers in the class had been compared statistically in a number of ways with the group of two hundred twenty of which they were a part, and their achievements had been found not to be significantly different from their group. They became, then, the sample for the summer group.

The classes for the fall and spring had approximately the equivalent preparation in education and psychology, and in number of biological science courses. It was necessary to find representatives for all degrees of biological preparation, and still keep the selection random. The fall class was first considered. The questionnaires containing the necessary data were sorted into piles according to the number of biological courses indicated, using the five classifications listed in Table III. The per cent that each

classification was of the total enrollment for the semester was taken from Table III. The same procedure was used for the spring class.

Table III
Classification of Student Questionnaires in Sampling

Classification	Per cent	
	Fall Class	Spring Class
No courses in biology or hygiene	12	13
One course, biology or hygiene	23	24
Two courses, biology and hygiene	22	28
Three courses, biology and hygiene	15	16
Four or more courses, biology, hygiene	27	19

The entire enrollment of the fall class was now listed alphabetically, and the classification group indicated for each student. The spring class was similarly listed separately in alphabetical form and classified.

One hundred students were next selected from the alphabetical list of the fall class, in such a way that each group would be represented in proportion to its percentage in the total registration, and the spread would cover the alphabet, thus:

> Group 1. *No courses in biological science* forms 12 per cent of the fall group. Twelve students were selected by taking every fourth student listed as having no biological background, etc.

One hundred students were then selected from the spring class by pairing each one of the fall group, both as to biological background and exact education courses taken. This was possible in all but Group 5, where variations were very great. Here the closest possible similarity, in all cases including as many like courses as the first four groups, was accepted.

To determine whether the two hundred students so selected were really representative of the classes as a whole, the scores of an objective examination given at the end of the semester to the fall class were listed, classified, and compared with the distributions of the scores of the selected sample from this class, and also with the scores of a straight random sample made by taking every fourth student straight through the alphabetical list. The three distributions were compared statistically and no significant difference was found between the scores of the whole class and those of the selected sample. It was assumed that the sample selected from the spring class was also representative, since it was determined by pairing the individuals in the fall class, item for item. In checking and tabulating the

definitions from the fall sample, such a high percentage of errors and omissions was found that some doubt was felt as to the representativeness of the sample, and seventy-five additional papers taken at random from the pile were checked. The added sample failed to change the percentage of errors in any case as much as five per cent, and it was, therefore, assumed that the original sample of the class gave a fair picture of the comprehension of the class in respect to these particular words.

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Summary of Factual Questionnaire on the Training of Prospective Teachers of Science

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Throughout this report the following designations are used: (I) colleges or universities having departments of education; (II) state teachers colleges; (III) state normal schools; and (IV) city public normal schools. The lists of these institutions were obtained from the United States *Educational Directory:* 1931. Between September 15 and 20, 1931, 859 questionnaries were sent out to the following: (I) 623; (II) 142; (III) 69; (IV) 25. By October 19, 239 returns had been received as follows: (I) 151; (II) 61; (III) 20; (IV) 7. As further phases of the study necessitated an early analysis of these questionnaires, the tables are based on the total of 239, although additional returns were received after this date. The percentage of returns is (I) 24; (II) 43; (III) 29; (IV) 28; total 28. The sampling is representative, all states and territories being represented except Alaska, Delaware, and Vermont. In most cases, it is approximately 30 per cent. It is probable that a much larger percentage of returns would affect very little the conclusions stated in the summary.

It is to be noted that the colleges and universities outnumber the teachers colleges and normal schools by a large margin. Teachers colleges outnumber normal schools. There seems to be a tendency away from normal schools with two- or three-year curricula toward teachers colleges with four- or more-year curricula. Ninety-five per cent of the colleges and universities reporting offer curricula of four years or more; 90 per cent of the teachers colleges reporting offer curricula of four years or more; 53 per cent of the state normal schools offer curricula of two or three years, or less; 50 per cent of the colleges or universities offer graduate work beyond the fourth year; and 21 per cent of the teachers colleges offer similar graduate work. The city public normal schools are divided between the teacher-college and normal-school types and are so few in number that they will receive minor attention in this report. Thirteen states have no teachers colleges; 25 have no normal schools; 6 have neither teachers colleges nor normal schools. Some states have a great many colleges or universities; others have few. These facts raise the ever important problem of equalization of educational opportunity in the whole country; and the equally important problem of adequate specific training of teachers for our schools.

What particularized provisions are made in these institutions for training prospective teachers of science?

Seventeen per cent of the colleges and universities reporting make no specialized provisions for training teachers of science; 53 per cent prepare teachers for junior and senior high school only; 12 per cent for particular sciences only; and 10 per cent for science for grades 1 to 12 inclusive. Three of these institutions specifically prepare teachers of college science.

Forty-seven per cent of teachers colleges specifically train teachers of science for grades 1 to 12 inclusive. Eighteen per cent train only junior and senior high school science teachers; 8 per cent train only teachers of particular sciences; and 10 per cent make no particularized provisions for science teachers.

Forty-seven per cent of the state normal schools make particularized provisions for teachers of elementary science; 16 per cent for science in grades 1 to 12 inclusive; while 21 per cent make no special provision for training teachers of science as such.

Forty-two per cent of the city public normal schools specifically train teachers of science for the elementary grades only.

Considering all institutions reporting: 16 per cent make no specific provisions for training teachers of science; 39 per cent train for junior and senior high school only; 20 per cent provide for grades 1 to 12 inclusive; and 7 per cent consider only the elementary grades.

How do these institutions provide for specialization for science teaching?

Sixty-eight per cent of the 155 colleges and universities designated requirements in terms of majors and minors. This means that each student must have a major field in which he specializes and a minor field which is next in importance. Three per cent were for majors only, making a total of 71 per cent for majors, or majors and minors. Twenty per cent were for recommended, outlined curricula, and 6 per cent were for specialized, outlined curricula.

Seventy per cent of the designations from teachers colleges were for majors and minors or majors alone; 18 per cent were for recommended, outlined curricula; and 4 per cent were for specialized, outlined curricula.

Thirty-one per cent of the designations from state normal schools were for specialized, outlined curricula; and 16 per cent were for majors and minors. The tendency in these institutions is to train teachers of the elementary grades without much specialization.

Considering designations from all schools, 68 per cent were for majors and minors or majors alone; 19 per cent were for recommended curricula; and 8 per cent were for specialized curricula.

To what extent do teacher-training institutions offer special diplomas to prospective teachers of science as such?

Eighty-seven per cent of the colleges and universities offer no special diplomas; likewise 81 per cent of the teachers colleges, 80 per cent of the state normal schools, and 75 per cent of the city public normal schools. Seven per cent of the first give special diplomas to prospective secondary school teachers of science; likewise 11 per cent of the teachers colleges, and 10 per cent of the state normal schools. Few special diplomas are given.

What are the usual specifications for a major and for a minor?

Forty-eight per cent of all replies signify that a major shall be in one subject field of science; 36 per cent that it may be in several sciences; and 15 per cent that it is specifically outlined. Likewise 46 per cent signify that a minor must be in a science field; 40 per cent that it may be in a non-science field; and 14 per cent that it is specifically outlined.

In this questionnaire "professionalized" subject matter was defined as subject matter specifically designed for future teachers. The questionnaire sought to discover how many of the subject matter courses in science were "professionalized" courses. The median percentages for the four types of institutions were, respectively, 5.6, 16.8, 75, and 20; with 7.3 per cent for all. These percentages are the percentages of all subject matter courses offered which are "professionalized." In 89 per cent of colleges and universities, less than 10 per cent of the subject matter courses in science are "professionalized." The same is true for 37 per cent of the teachers colleges, 28 per cent of the state normal schools, and 33 per cent of the city public normal schools. Similarly, in none of the first type are 90 per cent of the science subject matter courses "professionalized." In 24 per cent of the teachers colleges, however, more than 90 per cent of the science subject matter courses are "professionalized." The same is true in 47 per cent of the state normal schools and in 16 per cent of the city public normal schools. Apparently the state normal schools have "professionalized" these courses to a greater extent than any of the other institutions, with the teachers colleges second, the city public normal schools third, and the colleges and universities last. In fact, the colleges and universities which train the greater portion of our teachers have done very little toward "professionalizing" their subject matter courses in science. If this "professionalization" may be assumed to be desirable, there is abundant opportunity awaiting the persons who can do the work.

What subject matter courses in science have been wholly or partly professionalized?

For colleges and universities, of 140 professionalized courses (an average of .9 courses per institutions), 38 are in biology; 30 in chemistry; 27 in

physics; and a much less number in general science, nature study, elementary science, and other sciences in the order given. For teachers colleges, of 195 professionalized courses (an average of 3.2 per institution), 38 are in nature study, 35 in biology, 30 in chemistry, 28 in physics, 24 in general science, 18 in elementary science, and 22 in other sciences. For state normal schools, of 46 such courses (an average of 2.4 per institution), 10 are in biology, 9 in nature study, 7 in elementary science, 6 in general science, and a less number in other sciences. For all institutions the rank order is biology, nature study, chemistry, physics, general science, and elementary science.

How many special methods courses are offered by these teacher training institutions?

For the four types of institutions, the average per institution is, respectively, 1.4, 1.8, .42, and .1. The teachers colleges and the colleges and universities evidently pay more attention to special methods courses. There are, however, none of these courses in 41 per cent of the first type, 26 per cent of the second type, 68 per cent of the third, and 86 per cent of the fourth. Perhaps it may reasonably be inferred that where the subject matter courses are "professionalized" to the greatest extent, there is less need for special methods courses.

For all institutions, the rank order of special methods courses is: biology, chemistry, secondary science as a whole, physics, general science, elementary science, science as a whole, and physical science, with others scattered.

To what extent are practice-teaching and observation courses offered by teacher-training institutions?

In a very few cases, practice teaching and observation are separate courses. In most cases, they are combined. The average per institution for the four types of institutions are, respectively, 2.3, 3.0, 1.1, and .8. Teachers colleges and colleges and universities evidently offer more of these courses as well as special methods courses. Perhaps this is because they are larger institutions and enjoy more facilities in the line. There are, however, none of these courses in 23 per cent of the first type, 16 per cent of the second type, 47 per cent of the third type, and 86 per cent of the fourth type of school.

For all institutions, the rank order in the number of practice-teaching and observation courses is: biology, chemistry, general science, physics, and elementary science, with the other sciences few in number and scattered.

How many and what kind of specialized courses in the teaching of science in addition to "professionalized" subject matter, special methods, practice teaching, and observation courses are being offered in teacher-training institutions?

Of the four types of institution represented, 86 per cent of the first offer no additional courses. Likewise 74 per cent of the second, 95 per cent of the third, and 100 per cent of the fourth. Colleges and universities rank first in the number of such courses offered because there are so many more of these institutions. The most frequent course is "Science Teaching," followed in order by "Researches in Science Teaching," "Supervision in Science Teaching," and "Problems in Science Teaching." The following courses appear with a frequency of one in the 239 institutions replying: "Science Education," "Seminar in Science Education," "The Curriculum in Science," "Trends in Science Teaching," "Materials and Methods in Science Teaching," "Laboratory Apparatus Construction," and "Laboratory Demonstrations and Techniques."

What teaching experience in typical school situations and what professional training have teachers in special methods courses in science teaching had?

The questionnaire data show that of 314 special methods courses reported, 81 per cent were taught by teachers having a minimum of five years experience in a typical school situation. Sixty-four per cent of these courses were taught by teachers having degrees from teachers colleges or schools of education, or diplomas from normal schools. It will be generally agreed that all teachers of these courses should have considerable experience in typical school situations, and that professional training is essential.

What curriculum requirements are being made in teacher-training institutions for prospective teachers of science?

Only colleges and universities and teachers colleges returned adequate information on this point. Generally the state normal schools make few specific provisions for science teachers, and the city public normal schools replying were few in number. Data were fairly complete for 95 colleges and universities and for 32 teachers colleges. The semester-hours of credit required in science subject-matter courses in the first type of institution ranged from approximately 15 to 60, with a median of 35.5 semester hours; and in the second from approximately 15 to 65 with a median of 35.0 semester-hours. For psychology, the range in the first type of institution was from none to approximately 20, with a median of 6.7 semester-hours; in teachers colleges, from 1 to 10, with a median of 6.5 semester-hours. For educational methods and philosophy, the range in the first type was from 0 to 50, with a median of 7.5 semester-hours; in teachers colleges, from 0 to 30, with a median of 8.7 semester-hours. For all pedagogical courses including psychology, special methods, practice teaching, and observation, the range in colleges and universities was from 5 to 50, with a median of 20.3 semester-hours; in teachers colleges, from 10 to 50, with a median of 24.2 semester-

hours. The two types of institution are not widely divergent, but the teachers colleges show some tendency toward more requirements in purely professional courses.

Suggested desirable provisions in training teachers who will teach science are:

1. Adequate training of teachers of science for grades 1 to 12, and college teachers as well. Create a demand for well trained teachers of science.

2. The use of majors and minors provides a good method for caring for differentiation, with certain requirements in strictly professional courses. Individual majors and minors should be determined by the kind of teaching the teacher expects to do.

3. Professionalize all subject-matter courses for prospective teachers except certain advanced elective courses the student may wish to take.

4. Special methods courses may be eliminated if subject-matter courses are properly professionalized.

5. Require adequate practice-teaching and observation courses comparable to the interneship of the medical profession.

6. Require of teachers in teacher-training institutions a minimum of five years in a typical school situation and adequate professional training in a teacher-training school.

Research Studies Related to the Teaching of Science*

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5. Selections and Organization of the Content of Science Courses

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Achievement in General Chemistry as It Is Related to Certain Learning Abilities*

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The fact has been recognized for a number of years that the percentage of failures in general chemistry is high. In spite of this fact there has been little effort to ascertain adequate bases for the improvement of instruction to the end that the number of those who fail may be reduced. It seems that systematic effort to improve instruction should be based on a study of the learning abilities concerned in the study of chemistry. This study concerns itself largely with a consideration of the fundamental learning abilities which may function in the study of general chemistry, and the relationship between such abilities and achievement in the subject.

It was found necessary to construct tests in order to measure the ability of students to read in the field of chemistry. Accordingly, the following named reading tests were constructed: The Expositive Reading Test, hereafter known as No. 1; The Chemistry Vocabulary Test, hereafter known as No. 2; and the Reading for Directions Test, hereafter known as No. 3. In addition to these three tests, two tests were constructed in order to measure the ability of students to select the steps that are necessary in solving a laboratory problem in chemistry, and their ability to rank those steps after they have been selected. These two tests are hereafter known as Nos. 4S and 4R. Each test was constructed in two equivalent forms, Form A and Form B. The textbook analysis technique was used to insure validity of reading selections and laboratory problems. The words selected for the vocabulary test were taken almost wholly from the Pressey Word List.[1] These tests were constructed in multiple-choice form and their reliability determined by administering them to a typical group of college students in beginning general chemistry. The correlation of form against form proved them to be satisfactory in this regard.

At the beginning of the term (1929-1930) in which this study was undertaken, the cooperation of five colleges in Missouri was secured, having a total enrollment in beginning general chemistry of about 325 students. These students were found to be, in all respects, typical college students of general

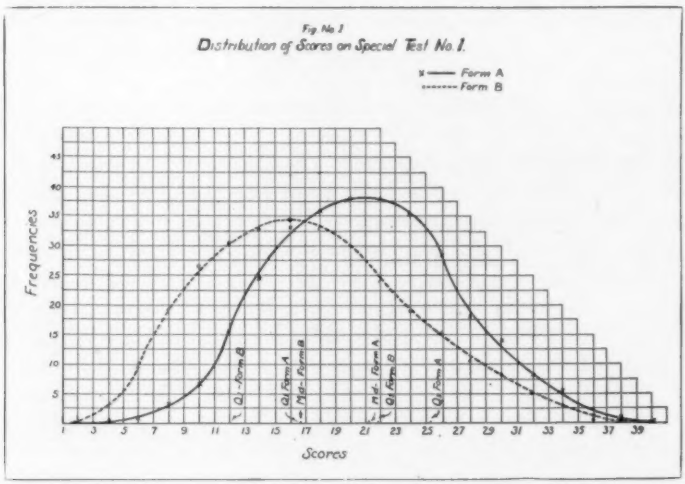
* This paper is abstracted from a Doctor's dissertation presented by the writer in the Graduate School of the University of Missouri in 1931, and published as Bulletin No. 6, Vol. XXXI, of the Northeast Missouri State Teachers College, Kirksville, Mo.

chemistry.* Within the first few weeks of the term, Form A of each of the special tests constructed for this study was administered, along with the Iowa Chemistry Training Test (Form A, Revised) and the Otis Self Administering Test of Mental Ability, Higher Examination (Form C). At the end of the fall quarter, Form B of each of the special tests was administered, as well as the Whipple High School and College Reading Test (Form B), the Holley Sentence Vocabulary Scales (Series 3B), and the Iowa Chemistry Training Test (Form B).

Results

Special Test, Number 1, Expositive Reading

This test is designed to measure the ability of students to read the kind of literature found in typical general chemistry textbooks. Figure 1 shows



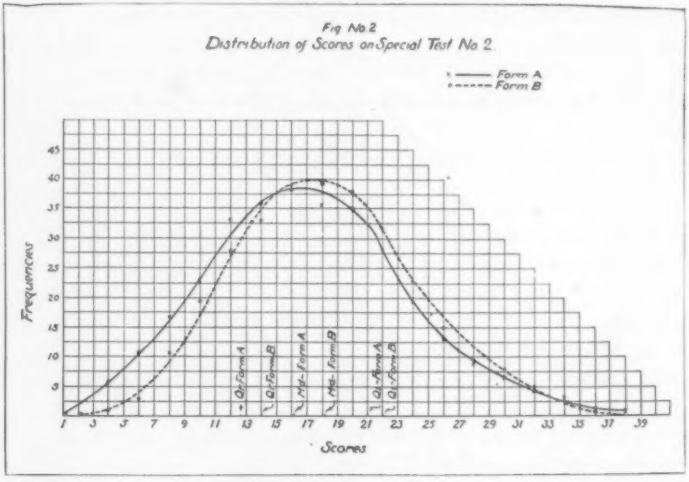
the distribution of scores on the two forms of this test. The mean score on Form A of this test is 22.05 out of a possible 40. This indicates that the average student reads this type of literature at the beginning of his study of college chemistry with an efficiency of about 55 per cent. The best student in the group scored 19.5 times as high as the poorest. The coefficient

* The five colleges cooperating in this study were: The Southeast Missouri State Teachers College, Cape Girardeau; the Southwest Missouri State Teachers College, Springfield; the Central Missouri State Teachers College, Warrensburg; Culver-Stockton College, Ganton, Missouri; and the Northeast Missouri State Teachers College, Kirksville.

of variability of the group is 29.32 for Form A. The Standard Deviation is 6.46. The mean score on the Form B of this test, given at the end of the term, was 16.85. This is appreciably lower than the mean of Form A of this test, although the two forms of this test showed high correlation on the pre-test with practically no difference between the means. No reason is given for this apparent decrease in the ability of students to read expositive chemical literature during their first quarter of study on the subject in college. There is certainty of a significant difference in favor of the mean of Form A over the mean of the Form B. The standard deviation of the Form B is 6.75 and the coefficient of variability is 40.05.

Special Test Number 2, Chemistry Vocabulary Test

This test is designed to measure the students' command of the technical vocabulary of general chemistry. Form A was given at the beginning and



Form B at the end of the quarter. Figure 2 shows the distribution of scores on the two forms of this test. According to this test, the average student knew 44.5 per cent of the technical words met at the beginning of the quarter. The best student had a technical vocabulary about 6.6 times as great as the poorest student in the group. The standard deviation is 6.4, and the coefficient of variability is 37.98 on Form A.

On the Form B of this test, the average student scored 47.5 per cent of the possible score. The poorest student would have to master about 87 per cent of the technical words met, while the best student would already

have mastered about 87 per cent of these words. When it is considered that each technical word carries with it a technical concept that cannot be easily mastered by merely studying the definitions given in a dictionary or a textbook, the significance of these data may be more readily understood.

The Reading for Directions Test, Special Test Number 3

It is recognized that reading for directions and reading of expositive material involve different abilities. This kind of reading ability functions in laboratory work when a student reads directions for performing an experiment, and then reacts to these directions. On Form A of this test the average student scored 78.5 per cent of the possible score, while on Form B the average student scored 73.1 per cent of the possible score. The distribution is strongly skewed negatively, yet the coefficients of variability (20.34 and 19.67) are sufficiently high to show that the test was difficult enough to scatter the group widely. No reason is assigned for the apparent decrease in the ability of students to do this type of reading during their first quarter of the study of chemistry in college. There is practical certainty of a significant difference in favor of the average of Form A over the average of Form B.

Special Test Number 4S

The ability to solve a chemical laboratory problem is not necessarily a reading function, and yet it is one that should play a part in the success of a student in general chemistry. This test is intended to measure the ability of a student to start with a definite chemical fact and determine the steps that would have to be carried out in solving a laboratory problem involving that fact or principle.

The average student performed with an efficiency of somewhat less than 42 per cent on Form A of this test. The poorest student in the group was not able to score on this test, while the best student was able to score 84.6 per cent of the possible score. The range of scores (34) and the coefficient of variability (51.22) both indicate the unusually great difference in the ability of students to do this kind of work.

All measures of central tendency and of dispersion are greater on Form B than on Form A which was given at the beginning of the term, the coefficient of variability alone being distinctly less on Form B. There is practical certainty of a real difference between the means of the two forms in favor of the mean score on Form B. This indicates an apparent increase in the ability of the students to select the steps necessary to the solution of chemical laboratory problems during their first quarter of study of the

subject of general chemistry in college. One is impressed with the fact that the variability of the group is so great on either form of this test that a large number of students would find themselves facing an almost impossible task if called upon to perform this kind of work. Most laboratory work done is not of this character, but consists of exercises in which the student merely follows printed directions in the laboratory. It has been shown that there is a definite, significant relationship between the ability to solve such problems as this test presumes and achievement in general chemistry, as measured by the Iowa Chemistry Training Test. In view of this fact it might be well for teachers to look with greater favor upon this kind of laboratory work.

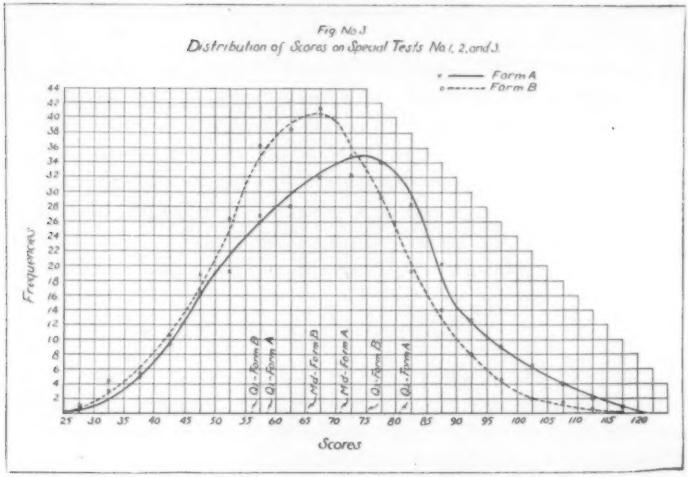
Special Test Number 4R

In solving a laboratory problem in chemistry it seems evident that the student should be expected not only to select the necessary steps to take in solving the problem, but also to rank the steps in the order in which they would have to be carried out in the laboratory.

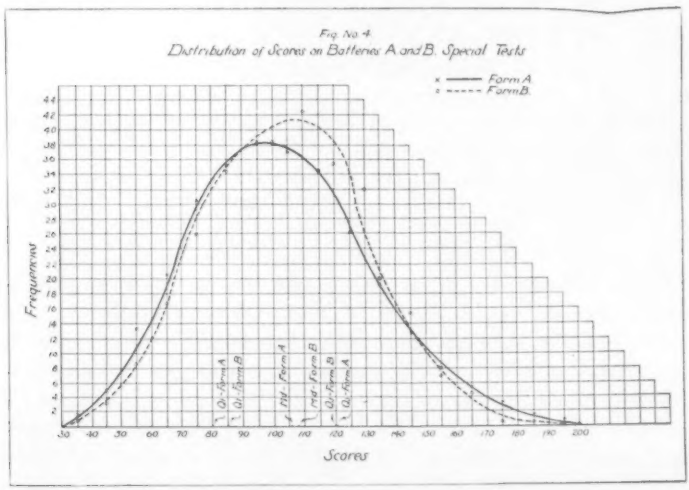
The average student in the group scored only 36.2 per cent of the possible score on the Form A of this test. The poorest student in the group was unable to score on this test, while the best student in the group scored 84.6 per cent of the possible score. The measures of central tendency on Form B are all greater than those on Form A, while the variability in the case of Form B is considerably less than that on Form A. The coefficients of variability (49.61 and 38.73) are both very high, indicating a wide range in ability of the students to perform this kind of work. There is practical certainty of a real difference in favor of the mean of the Form B over the mean of Form A of this test, which indicates that there is an apparent increase in the ability of the students to perform this kind of work after one quarter of study of the subject in college. The average student, however, does not seem to be able to perform this kind of work with anything approximating satisfactory efficiency.

Special Tests Number 1, 2 and 3, combined as a battery

Figure 3 shows the distribution of scores on the battery of tests composed of Special Tests Numbers 1, 2, and 3 arranged to measure, in one set of scores, the ability of the students to read chemical literature. The average student performed with an efficiency of 57 per cent on Form A of these tests, and 56 per cent on Form B. The standard deviations are 15.93 and 14.33 on the two forms of this battery. When the three separate measures of reading are considered together there is not certainty of a decrease

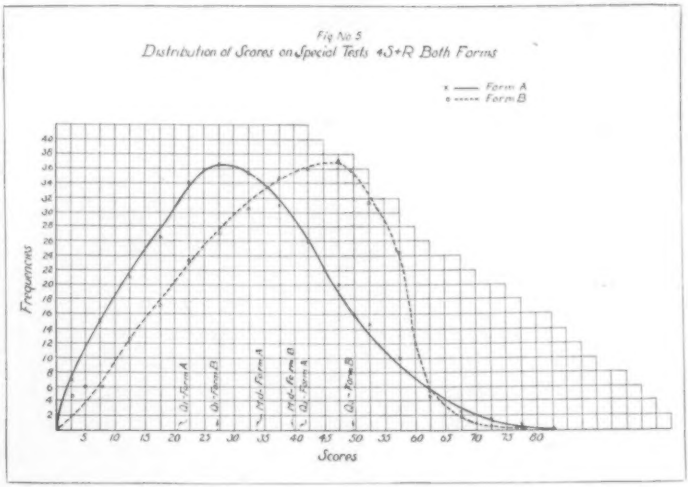


in the ability of students to read the chemical literature after one quarter of study of the subject in college. This, however, supports further the belief that the ability to read chemical literature is not a simple function, but may be made up of several quite distinct abilities, certain of which may increase or decrease independent of the others during the period when the student is endeavoring to orient himself in the study of a new subject.



Special Tests Number 4S and 4R, as a Battery

When the scores on Special Tests Numbers 4S and 4R are arranged as a battery the combined scores should measure the ability of the students to solve a chemical laboratory problem. Figure 5 shows the distribution of scores on this battery.



The Whipple Reading Test

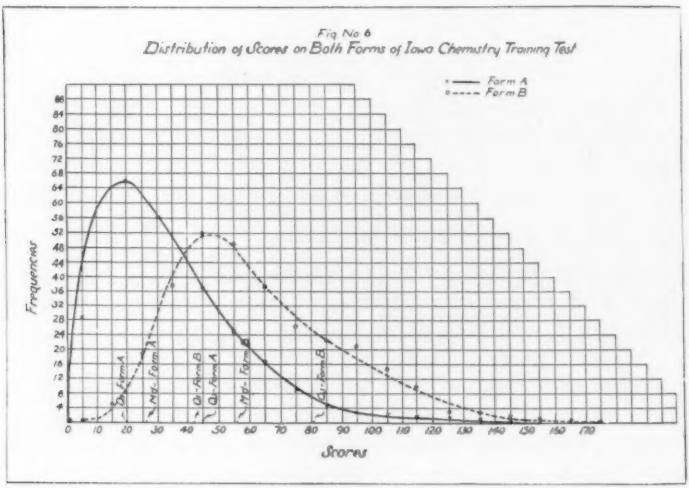
In order to measure the general reading ability of the students the Whipple Reading Test was administered. As measured by this test the average student read with an efficiency of 44.7 per cent of the possible score. The standard deviation is 6.25. The coefficient of variability (66.91) is so exceptionally high that it appears to be especially significant. Whipple states in his directions for using the Whipple Test that "unless otherwise explicable, a low score in this test (say below the 20th or the 10th percentile point) raises the presumption that the student has distinctly inferior reading ability in silent reading generally. Unless he can remove this handicap by special training in reading he should be either discouraged from undertaking advanced academic work or should be prepared to follow a reduced schedule of courses with corresponding lengthening of the time needed for graduation." About 12.8 per cent of the present group of students fall within the limits set by Whipple for "distinctly inferior" readers, while about 14 per cent of the present group read with an efficiency that would place them above the 90 percentile point.

The Holley Vocabulary Scales

In order to measure the general word knowledge possessed by the students of this group the Holley Sentence Vocabulary Scales were administered. Reading is based not only on a knowledge of technical words, but also on the command of general vocabulary. There is no doubt but that success in reading depends to a large extent on the ability of the reader to comprehend accurately and quickly the meaning of the words used. It was found that the average student would probably know about 64 per cent of the words which he would need, as measured by this test. The standard deviation is 8.47 while the coefficient of variability is 18.92.

The Iowa Chemistry Training Test

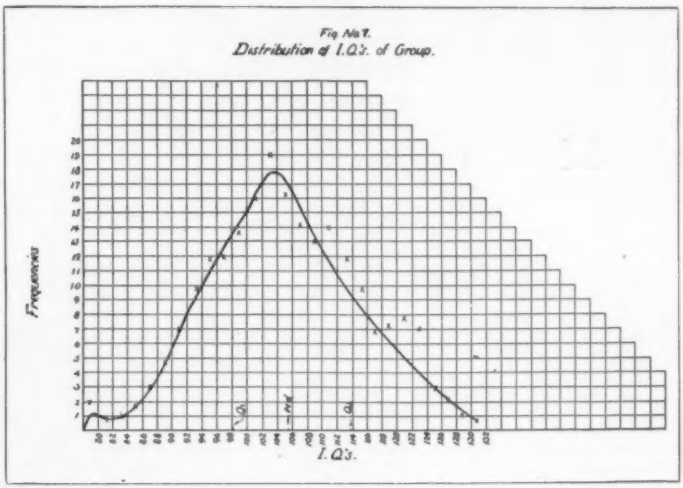
Figure 6 shows the distribution of scores on the two forms of the Iowa Chemistry Training Test. The average student in the group scored 18 per



cent of the possible score at the beginning of the term. The poorest student scored one on this test, while the best student scored 141 out of a possible 188. The mean score on the Form B of this test was nearly twice as high as the mean of Form A. The standard deviations are 22.65 and 26.75 respectively while the coefficients of variability are 66.67 and 42.74 respectively. At the end of the term the scores ranged from 10 to 163.

Intelligence Quotients

Whatever may be one's attitude toward the intelligence quotient as a measure for use in the study of college students, the fact is that it is being widely used and that it does seem to bear a significant relationship to achievement in academic fields. Figure 7 shows the distribution of intelligence quotients of the students of this group, the average age of whom was found to be 19.25 years. The mean intelligence quotient is 105.94. The range is from 79 to 131, with a standard deviation of 10.33.



A Study of Achievement in General Chemistry as Related to Performance on Other Tests

Table I shows the coefficients of correlation of the first Chemistry Training Test scores with scores on other tests.

Battery A of the Special Tests, correlated with the Chemistry Training Test, gives a predictive index of 27.62, according to the method given by Hull.[2] The intelligence quotients correlated with CT1-A scores give a predictive index of 11.73. The battery of special tests, and also Special Test No. 2A, have predictive values that approach closely the maximum predictive value of modern tests as given by Hull.

Table II gives the coefficients of correlation of the second Iowa Training Test scores with scores on other tests.

TABLE I

CORRELATION OF CT1-A SCORES WITH OTHER TEST SCORES

Test	r ± P.E.	
Special Test No. 1A	0.55	.025
Special Test No. 2A	0.67	.022
Special Test No. 3A	0.34	.035
Special Test No. 4AS	0.55	.027
Special Test No. 4AR	0.44	.032
Special Tests No. 1, 2, and 3, Form A	0.58	.026
Special Tests, Battery A complete	0.69	.021
Whipple Test (Reading)	0.29	.036
Holley Vocabulary Test	0.37	.038
Intelligence Quotients	0.47	.035

TABLE II

CORRELATION OF CT1-B SCORES WITH SCORES ON OTHER TESTS

Test	r ± P.E.	
Special Test No. 1B	0.55	.027
Special Test No. 2B	0.60	.025
Special Test No. 3B	0.18	.037
Special Test No. 4BS	0.41	.033
Special Test No. 4BR	0.41	.033
Special Tests No. 1, 2, and 3, Form B	0.56	.027
Special Tests, Battery B, complete	0.54	.027
Special Tests No. 4BS and 4BR	0.39	.033
Whipple Reading Test	0.33	.035
Holley Vocabulary Test	0.34	.035

TABLE III

CORRELATION OF TEACHERS' MARKS WITH SCORES ON VARIOUS TESTS

Tests	r ± P.E.	
Special Test No. 1B	0.45	0.031
Special Test No. 2B	0.41	0.033
Special Test No. 3B	0.09	0.039
Special Test No. 4BS	0.40	0.033
Special Test No. 4BR	0.33	0.033
Special Tests No. 1, 2, and 3, Form B	0.41	0.037
Special Tests, Battery B complete	0.47	0.031
Special Tests No. 4BS and 4BR	0.37	0.033
Holley Vocabulary Test	0.13	0.0042
Whipple Reading Test	0.25	0.036
Intelligence Quotients	0.26	0.042

The correlations in Table II tend to support the conclusion that reading in the field of chemistry is a rather specific function which may not be accurately measured by instruments intended to measure general reading ability in other fields.

The correlations of teachers' marks with other scores are given in Table III.

It is seen that most of the correlations shown in Table III are too low to be of any special significance and all are lower than the coefficients of correlation shown in Tables I and II wherein the same test scores are correlated with the scores made on the two forms of the Iowa Chemistry Training Tests.

Table IV shows the coefficients of correlation of some of the tests with intelligence quotients.

TABLE IV

CORRELATION OF INTELLIGENCE QUOTIENTS WITH OTHER TEST SCORES

Tests	r ± P.E.	
Special Tests No. 1, 2, and 3, Form A	0.70	0.024
Special Tests, Battery A complete	0.70	0.024
Special Tests No. 4AS and 4AR	0.52	0.036
Whipple Reading Test	0.64	0.026
Holley Vocabulary Test	0.56	0.033

An examination of Table IV shows that there is a substantial relationship between intelligence quotients and scores made on the batteries of special tests.

Partial correlation studies strongly support the conclusion that, of all the measures used in this study which might be used for predictive purposes, the special tests constructed for this study have the highest value in predicting success in the study of chemistry.

Summary of Results

The results of this study seem to justify the following conclusions:

1. The average student reads expositive chemical literature with an efficiency of not greater than 55 per cent.

2. Even the superior students had great difficulty in selecting and stating the central theme or main thought of reading selections.

3. The average student probably has a general reading efficiency, as measured by the Whipple Test, of not to exceed 44.7 per cent.

4. The average student at the beginning of his study of college chemistry would probably not know more than 44.5 per cent of the technical words met in a typical chemistry textbook.

5. The average student of college chemistry would probably not know more than 64 per cent of the non-technical words met in his study.

6. There is a significant relationship between chemistry achievement, as measured by the Iowa Test, and the ability to read chemical literature, as measured by the battery of special tests.

7. As measured by the battery of Special Reading Tests, the average student probably reads chemical literature with an efficiency of not greater than 57 per cent.

8. There is an extremely wide range of ability of students to learn chemistry, as measured by the special tests.

9. The average student at the beginning of his study of college chemistry would probably not be able to score more than 18 per cent of the possible score on the Iowa Test. The range of scores is so great (1-141) that it constitutes a major teaching difficulty in any college where classes cannot be sectioned on the basis of ability.

10. A study of the results of partial correlation indicates that, of all measures employed in this study which might be used for predicting the probable success of students in the study of general chemistry in college, the battery of special tests is most efficient.

Conclusions of Pedagogical Significance

President L. D. Coffman, of the University of Minnesota, in discussing the improvement of instruction in institutions of higher learning said:

> The efficiency of our higher institutions of learning in the future will be dependent upon . . . the extent to which they guide students wisely, train them in proper habits of thinking, become interested in their individual abilities and personal welfare, reorganize the materials of instruction, improve the methods of teaching, introduce programs of work adapted to modern society and to the needs of the students.[3]

It has been pointed out in this study that extreme differences exist in the ability of students to perform those basic functions that seem to condition success in the study of general chemistry. The question naturally arises as to how to meet the problem of the individual differences in the ability of students in the usual classroom situations.

It seems obvious that if the problem which has been pointed out is to be solved, there must be serious effort at individualization of instruction. This study does not presume to prescribe exact means for meeting all of the difficulties that have been pointed out in connection with this problem. That is a proper topic for another investigation. There are, however, some general observations that might be made bearing on the pedagogical implications of this problem.

It should be obvious that discovery of the disabilities of the individual student should be discovered for the purpose of remedial treatment, if possible, while specific abilities should be discovered for the purpose of being nourished and encouraged. It would appear that the time has passed when the teacher, even of college classes, can justify an attitude of indifference toward the specific problems of the individual student. Students should be dealt with as individuals and not collectively. The student who has a reading disability in chemistry should be given every encouragement and assistance by the teacher in meeting his problem. Georges states that "systematic corrective work must be based upon information, not on guesswork."[4]

College students in certain institutions are being taught to read after they enter as freshmen. Pressey and Pressey have shown that students entering Ohio State University with reading disabilities can be taught to improve their reading.[5] These investigators are of the opinion that training in general reading ability is likely to carry over and show improvement in all fields of work. Miller has also demonstrated in his studies at Christian College that college students can be taught to improve their reading.[6] Similar conclusions have been drawn by E. S. Jones at the University of Buffalo, C. C. Crawford at the University of Idaho, H. H. Remmers at Purdue University, W. F. Book at Indiana University and A. C. Lemon at the University of Iowa, while A. C. Eurich, in the University of Minnesota, is not so hopeful.

The fact should be noted, in this connection, that practically all of the remedial work referred to above has been carried on in the field of general reading, which, according to this study, does not bear a significant relationship to achievement in general chemistry. Very little work was reported on the improvement of reading in the technical field of chemistry. It appears that reading of chemical literature involves reading disabilities not found in general reading. O'Brien says, "Different modes of reading, different types of reading attitudes are induced by different kinds of subject matter. There are highly complex patterns of reading, highly individuated, not one uniform mechanical procedure."[7] It is felt, therefore, that both diagnostic and remedial measures should be specific.

It must not be forgotten that the instructor owes fully as much to the superior student as he does to the less fortunate or retarded ones. In many cases the superior student is not stimulated to work to full capacity, with the result that he often develops habits of indolence and indifference which limit his later growth and development.

One can hardly hope that individual differences will cease to exist. As long as students are born with different capacities for intellectual activities, just so long may we expect to be faced with the problem of individual

differences in whatever ability we may care to consider. It seems that individualization of instruction has lead to the point where educators should be prepared to make as careful a diagnosis as possible of the abilities and disabilities of each student, and plan for his intellectual development with all of the care and precision of the trained physician who ministers to the physical man.

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[6] MILLER, J. C. An unpublished study made in Christian College, Columbia, Missouri, 1930.

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Abstracts

General Education

BENEDICT, RALPH C. "What Effect Do You Have on Your Pupils?" *School Science and Mathematics* 31: 836-840; October, 1931.

This article presents a score sheet intended to be helpful to supervisors and teachers for rating the quality of teaching.
—A.W.H.

BRAKELEY, GEORGE A. "Tuition and Cost of Education." *The Educational Record* 12: 312-321; July, 1931.

What part of the cost of his education should a student pay? The author compares past and present practices with probable future tendencies in answering this question. Tuition charges have been greatly increased within the last few years and the chances are that there will be further increases. However it is a difficult question to determine what proportion of the education cost should be borne by the student. The author indicates the various factors involved and states as his conclusion that, normally, tuition should not be expected to pay over half of a student's education cost.
—C.M.P.

BUCKNER, MABLE A. "A Study of Pupil Elimination in the New Haven School." *The School Review* 39: 532-541; September, 1931.

The author made a study to determine why New Haven high school pupils left school before graduating. The study involved 801 pupils who left school during the years 1923-27. Personal interviews were had with 196 pupils. Factors affecting elimination were: over-ageness; failure in one or more school subjects; personality traits; intelligence; attitude of individual toward school; economic conditions.
—C.M.P.

CROFOOT, MENTHA. "Amount of Time Spent in School Work in Terms of Teacher Hours and Pupil Hours." *Educational Administration and Supervision* 217: 446-452; September, 1931.

This summarizes the findings of a study carried out in the public schools of Bremerton, Washington. Seventy-nine teachers were included in the study. The average grade teacher spent 17 hours, 18.57 minutes in out-of-class work each week in such activities as preparation of assignment, correction of papers, make-up work for students, extra-curricular activities, and miscellaneous duties. The average grade teacher spent 43 hours 47.19 minutes weekly in her school work. In high school the time 22 hours, 37.58 minutes in out-of-class work and 48 hours, 30 minutes in all school work. Science teachers ranked slightly below the average in both out-of-class work and in total school work. Summaries are given for each subject-matter teacher.
—C.M.P.

JACOBS, CHARLES L. "Some Vital Problems in the Guidance of Candidates for Teacher Training." *California Quarterly of Secondary Education* 7: 60-66; October, 1931.

Teaching is no longer a free-for-all occupation open to anyone and everyone who fails to find something more lucrative to engage his time. Teaching is definitely a profession, requiring precise preparation and with the oversupply of teachers now existing in every state, higher standards of qualification can be and are being demanded. Who shall be advised and encouraged to enter the teaching profession? The author lists twenty-five teaching traits which were compiled under the di-

rection of W. W. Charters. Prospective teachers might well rate themselves as to these traits, and should also ask themselves certain other questions which the author has included. —C.M.P.

Williams, Lewis Ward "Turnover Among Secondary Teachers in Illinois." *The Phi Delta Kappan* 14: 37-39; August, 1931.

This article is an abstract of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education in the Graduate School of the University of Illinois, 1931. The investigation had as its purpose the determination of teacher turnover in the high schools of Illinois accredited by the University of Illinois. Chicago high schools were not considered. The period covered ten years, 1921-1931. Findings were: teacher turnover varied from 38.7 per cent in 1921 to 18.6 per cent in 1930, with an average of 25.4 per cent. Turnover is greatest in small schools and tends to decrease as size of school increases. There is not much variation in the rate of turnover for teachers in the various subject-matter fields. Both teachers and principals give professional factors as the chief cause of turnover and economic factors as the second cause. —C.M.P.

Wright, Frank L. "A Comparison of College and University Graduates with Graduates of Teachers College in their Preparation as Prospective Secondary Teachers." *Educational Administration and Supervision* 17: 453-461; September, 1931.

This is the résumé of a study made by the author to determine the training of secondary teachers who graduate from different types of educational institutions. The high school and college records of 34 graduates from Teachers College A, of 54 graduates from Teachers College B, of 45 graduates of a school of education of a university, and of 61 graduates of the arts college of a private university, were analyzed. Wide variation was found in the type of training received. The average number of semester hours devoted to science in this institution were: Teachers College A, 15.8; Teachers College B, 9; School of Education, 18; Arts college, 14.5. Students from the school of education were prepared to teach a greater number of subjects. The author urges further research to determine what education teachers actually receive and which type of education is most conducive to good teaching, as evidenced on the job.

—C.M.P.

Science Education in General

Neureiter, P. R. "A Comparison of Science Curricula in European and American Schools." *Journal of Chemical Education* 8: 2040-2045; October, 1931.

The education of a French and German scientist is briefly outlined from the first grade up to the reception of the doctor's degree. The author, who has lived in Europe for twenty-eight years but had taught in an American college for the last three years, believes that the European student is prematurely forced into the narrow path of specialization, that he lacks guidance and encouragement and those beneficial influences which tend to mold him into a good citizen. In respect to American education, he believes that the American Liberal Arts College is superior to anything which European education has to offer, but that we are neglecting the exceptionally gifted students.

—C.M.P.

Platt, Washington and Baker, Ross A. "The Relation of the Scientific 'Hunch' to Research." *Journal of Chemical Education* 8: 1969-2002; October, 1931.

The authors, by means of a questionnaire, made an attempt to determine whether or not "hunches" or "intuition" entered into the discoveries made by some of the leading scientists selected from the latest edition of "American Men of Science." A total of 232 replies were received from the 1,450 questionnaires sent out. Representatives' replies have been quoted at length.

In general there seem to be two types of

research workers. The one type first gets a working hypothesis and then accumulates data to test it. The second type accumulates data until the general theory underlying them becomes obvious. One type is the guesser type and the other the accumulator type. Both types seem to exist among the scientists in approximately equal numbers. Replies appear to prove that certain conditions are favorable for creative mental achievement and that certain other conditions are usually unfavorable.

—C.M.P.

Touton, Frank C. "Research Projects of the Secondary School Level Carried on in California Cities During 1930-1931." *California Quarterly of Secondary Education* 7: 86-111; October, 1931.

This is the third compilation of research projects carried out in the secondary schools of California. Each project is reported by city, title, person responsible, nature of project, and findings. A total of sixty-two projects are reported. Those relating to science were: "Science Interests" carried out by Charles H. Nettels in the Los Angeles Schools (Reported in *Science Education* in March, 1931 and May, 1931); "Predicting Success in the Study of Chemistry" by James F. Bursch of the Sacramento Public Schools; "Equipment Standards for General Science, Grades 7, 8 and 9" by Arnold Joyal and R. E. Rutledge of the Oakland Public Schools; "Textbook Adoption and Evaluation Procedures" by M. E. Herriott of the Los Angeles Public Schools. In the latter study chemistry, physics, and general science were among the subjects evaluated.

—C.M.P.

Science in Grades Seven, Eight, and Nine

OSBURN, DOROTHY FRANCES. "The Use of Visual Aids in Teaching General Science by a Contract Method". *California Quarterly of Secondary Education* 7: 14-18; October, 1931.

Types of visual aids which the author has found useful in teaching general science by the contract plan in the Westlake Junior High School of Oakland are: exhibits, models, excursions, pictures, charts and diagrams, maps and globes, stereographs, stereoptican slides, still films and motion pictures. Three topics are selected as examples to illustrate the use of visual aids in teaching general science by the contract plan: "The Solar System and Its Neighbors," "Science in Industry," and "The Contributions of Science to the Modern Home."

—C.M.P.

NICHOLS, M. LOUISE. "Adaptation of Tests in Science to Differing Abilities". *School and Society* 34: 409-412; September 19, 1931.

The writer reports the results obtained from a series of science tests given to ninth grade girls in the South Philadelphia High School for Girls. The girls were one or more years retarded and had intelligence quotients ranging from 75 to 121. The author concludes from her study that tests for those of a lower I.Q. must present only a few items and that these few must be of a concrete nature. Application of principles to new situations can be expected only when the new situation differs but slightly from one that is already familiar.

—C.M.P.

SICHLER, ELIZABETH G. "A Socialized Science Project." *School Science and Mathematics* 31: 829-835; October, 1931.

This is an account of an experiment contrasting the work of a "recitation class" with a "project class" in general science. The first was the conventional type and the second a socialized-project type. Test results showed the conventional plan equal to or exceeding the socialized project plan, with three sets of pupils, but the experimenter contends that certain unmeasured, observed characteristics in the realm of attitudes and habits showed the superiority of the latter plan for junior high school science.

—A.W.H.

Science in the Senior High School

BERRY, PAULINE G. "The First Year Chemistry Course". *Journal of Chemical Education* 8: 1781-1815; September, 1931.

Chemistry teachers will find this a most useful article. A carefully worked out program for use of supplementary material contained in the *Journal of Chemical Education* and *The Chemistry Leaflet* is outlined. The year's chemistry work has been divided into weekly units in such a manner as closely to parallel the sequence of topics found in the usual high-school chemistry class. The topics selected for each week's work are the result of an analysis of several high school textbooks. The outline for each week's work includes: Material in *Chemistry Leaflet* devoted to a particular topic; related articles in past issues of *Journal of Chemical Education;* visual aids; motion pictures; and suggested chemistry club programs.

—C.M.P.

BALLEW, AMER M. "Notebook Work in Biology and Training in the Scientific Method of Thinking." *School Science and Mathematics* 31:822-826; October, 1931.

This article is a plea for less descriptive and more analytic drawings in the biology notebook. Laboratory exercises should be for the purpose of solving problems and this problem-solving attitude should be in evidence at all times. Laborious, encyclopedic notebook work should be abolished. The article was stimulated by, and is in keeping with Baird's study of biology notebook work in New York State.

—A.W.H.

MONAHAN, A. C. "Science Instructors Take Account of Stock." *School Science and Mathematics* 31: 849-852; October, 1931.

A plea for better equipped science laboratories.

—A.W.H.

DOWNING, E. R. "Teaching Units in Biology—An Investigation." *North Central Association Quarterly* 5: 453-467; March, 1931.

This article gives an account of the teaching of four units in biology in seventeen schools in the middle west, in order to determine the time necessary to produce mastery in the unit. The units and tests are given in the article, together with scores of pupils from several schools. The "mastery curve" is obtained in a few cases. Results indicate that probably not more than eight or nine teaching units which are planned to develop the understanding of a principle of science can be taught in a school year to the point of mastery. A plea is made that colleges should prepare teachers to teach "consumer science" largely by means of a "demonstration method", to develop ability to "think scientifically", which is really ability to solve problems by applying the principles of science.

—A.W.H.

HURD, A. W. "Additional Studies Relating to Physics." *North Central Association Quarterly* 5: 471-493; March, 1931.

This article includes (1) a report on preliminary and final test records from fourteen instructional units in physics taught in 25 schools in 23 cities in 14 states during the school year 1929-1930; (2) an analysis of responses to preliminary and final test items for one of these units, "Electric Lighting Systems", with an explanation of a basis for eliminating or retaining certain items for further use in experimentation seeking to discover better materials for instruction in high school physics; and (3) a summary of teacher opinion on some phases of instruction brought into question by the experimentation. Some suggestions are made on how to secure more satisfactory achievement records and on the rôle of experimentation in improving materials and methods of instruction. Concentration on a smaller number of teaching units for minimum essentials and a project program to care for individual differences are recommended.

—A.W.H.

FAY, PAUL J. "The History of Chemistry Teaching in American High Schools". *Journal of Chemical Education* 8:1533-1562; August, 1931.

Chemistry has been an important offering in the high-school curricula since the establishment of the first high school in Boston in 1821. The author briefly traces the history of chemistry teaching in the secondary schools. During the first three-quarters of the nineteenth century chemistry teaching was superficial, but rather practical. This period was followed by one in which laboratory work tended to dominate and mental discipline became the commonly accepted aim. Social objectives, greater emphasis on practical applications, and better adaptation to the needs and interests of pupils have characterized the trends since 1910.

—C.M.P.

GUNTHORP, HORACE. "Checking and Grading Laboratory Drawings." *School Science and Mathematics* 31: 846-848; October, 1931.

Suggestions on the author's plan of correcting and grading biology laboratory notebook work during the laboratory period.

—A.W.H.

HURD, A. W. "The Workbook as an Instructional Aid". *The School Review* 39: 608-615; October, 1931.

This is a résumé of a study made to determine the value of the workbook as an instructional aid in teaching high school physics. The study involved sixteen physics experiments and 1,125 pupils of whom there were 280 pairs in matched groups. Pre-tests and final tests were given and the gains noted. Eight experiments showed consistent differences favoring the group using work sheets, three being significant to the degree of certainty. Four experiments showed consistent differences favoring the groups not using work sheets, two being significant to the degree of certainty. Two experiments showed little difference between groups using and not using work sheets. The author concludes that work sheets tend to help pupils in situations like those studied, but that they are not indispensable. Workbooks seems to have the following values: (1) they are shown to be helpful to some teachers in increasing measured achievement, (2) they will not serve as a panacea to remedy all the inadequacies of present instruction, (3) they probably are particularly useful in directing the attention of both pupils and teachers to specific items of knowledge, techniques, and appreciations.

—C.M.P.

LANCELOT, W. H. "The Course in High School Chemistry." *North Central Association Quarterly* 5: 494-507; March, 1931.

This article suggests fourteen teaching units for a course in high school chemistry. One unit, "The Relation of Chemistry to Human Health," is printed in full. Twenty teachers used this unit experimentally and "found it satisfactory". Several comments of these teachers are given. They attest the "soundness and validity of the standards for reorganization of high school curricula" which were followed in the development of the unit.

—A.W.H.

PETERSON, HUGH W. "Status of Chemical Education in Utah Senior High Schools". *Journal of Chemical Education* 8: 2079-2086; October, 1931.

Fifty schools replied to the questionnaire, 42 of which taught chemistry. Some of the findings were: 14 per cent of the high school students were enrolled in chemistry; 38 per cent of the chemistry teachers had an undergraduate major in chemistry; the median number of chemistry credits was approximately 33 quarter hour credits per teacher; in general the chemistry teachers have had considerable teaching experience; physics and algebra are the other subjects most commonly taught; very few young and no old teachers are teaching chemistry; about one-third of the teachers devote 40 to 100 per cent of their time to chemistry teaching.

—C.M.P.

New publications

WATKINS, R. K. and BEDELL, R. C. *Learning and Test Activities in General Science.* New York: The Macmillan Company, 1931. 184 p. $0.60.

This is a workbook with unit tests for use in general science classes. Thirteen units are suggested with definite topical headings. Learning exercises are given, to be used as pupils need them for an understanding of the unit topic. Each unit includes (1) "Additional Things To Do"; (2) "Suggested Reading"; and (3) "A Summary of Facts and Principles To Be Remembered." In the last half of the book are given preliminary and final tests, respectively, for each unit. Content is borrowed from the fields of physical geography, biology, and physics primarily.

The book will be helpful to many teachers in securing more satisfactory achievement in general science. It is not too difficult for average ninth-grade pupils in our public schools. The selection of topics might be criticized but the topics are, on the whole, good when compared with those usually offered. All references are to books other than general science textbooks. Laboratory experiments are included. The tests are of the "new type" variety, there being several varieties of these tests used. Less use of uncompleted statements might improve the work exercises. —A.W.H.

MOTT-SMITH, MORTON. *This Mechanical World.* New York: D. Appleton and Company, 1931. 233 p. $2.00.

The author has made a successful attempt to humanize physics, especially that part of it dealing with mechanics. His ability to explain the phenomena relating to machines without resorting to mathematical treatment ought to appeal to the high school boy or girl, or to the layman. Weaving his story around interesting historical incidents the author describes the methods by which the basic mechanical laws were derived. These basic principles have stood the test of time and are not in any danger of being displaced. An understanding of these principles enriched by an acquaintance with their historical setting, is necessary for a true appreciation of our machine civilization.

The book is scientifically accurate and has a literary style that will appeal to high school students. It is recommended as a supplementary science reader for students who are studying mechanics in high-school physics. —C.M.P.

SPINNEY, LOUIS BEVIER. *A Text-Book of Physics.* New York: The Macmillan Company, 1931. 679 p. $3.75.

This textbook is a revised edition of the author's former text. In the preface, the author explains the changes which he has made. These are particularly in increased stress on applications and more detailed aids in solving problems. The organization on the whole, however, is quite conventional, but is free from the extreme mathematical and highly technical treatment used by many authors. It contains much content of a readable nature so that the student who is not mathematically inclined may still feel capable of securing great benefits from the course which is based upon this text.

Apparently, the author, from his teach-

ing experience, has observed some student dissatisfaction, incapacity, and disinterest in extremely conventional treatments of physics, and has attempted to overcome these deficiencies without adopting any really new organization or viewpoint. His large divisions are: Mechanics; Heat; Electricity and Magnetism; Sound; and Light. In the introduction, there is an expressed intent to follow a logically developed plan around the general topic of energy and energy transformations outside of chemical reactions. This intent has not affected the text organization or treatment, however. The problems are often highly theoretical—not always interesting to the practically-minded person. In the author's mind, there is apparently a possibility of a radically different organization, but he has not thought it timely to break far away from the conventional understanding of the college course in physics.

The book will make a good college text of the conventional sort, but is not essentially unlike many others now obtainable.

—A.W.H.

KRENERICK, H. CLYDE, *A Manual of Experiments and Projects in Physics*, New York: D. C. Heath and Company, 1931. 184 p. $0.84.

This laboratory manual of experiments and projects in physics has been written "to be used when there is perfect correlation between laboratory work and classroom discussion—not as a laboratory text but to accompany a text." The list of experiments, sixty-four in number, found in Part I, includes those usually found in physics laboratory manuals. Part II contains a list of twenty-one projects which deal more specifically with such practical aspects of physics as measuring the efficiency of various kinds of heaters, stoves, motors and flatirons. Some attention is devoted to the study of the automobile. Optional experiments are listed after each of the required experiments.

—C.M.P.

BROWNELL, HERBERT. *Physical Science*. New York: McGraw-Hill Book Company, 1931. 313 p. $2.50.

This book was written to serve as an introduction to more technical courses in physical science in teachers colleges and normal schools. It is organized into eight units representing various phases of physical science, although the units have not been named. Each unit consists of one or more chapters. Some units are based upon materials from physics; others from chemistry, physical geography, geology, and so on. There are additional units touching on general topics of educational interest, such as the achievements of science and educational values of science teaching. The appendices include useful supplementary materials on the wonders of the world, notable events in aviation, biographies of men of science, lists of books and periodicals, laboratory exercises, comments on teaching aims, and a vocabulary of new terms used in the book.

The style is natural, interesting, and easy for a mature, non-technical reader. It avoids the difficulties of higher mathematics and highly technical phraseology. It is, however, accurate and may be depended upon to give a good orientation, especially for teachers of general science. It represents a pioneering effort in general science on the college level in physical science only.

The good points of the book are: (1) it gives a general overview of general science; (2) it appeals to the interests of all; (3) it vitalizes science because it emphasizes the many ways in which science touches the daily life activities of all; (4) it apprehends the new conception of education for everybody; (5) it is forward-looking because it shows a commendable breaking away from outgrown viewpoints; (6) it is a relatively new attempt in the field, but one which will be welcomed by hosts of people; (7) it will help to prepare teachers of science, especially teachers of elementary and junior high school science; (8) it will help in fitting all science teachers to reveal the field of science in general to their pupils; (9) it popularizes science, making it understandable to all.

The author gives evidence of his training in conventional science and should be commended for his departure from the rigidly conventional organization.

—A.W.H.

HUNTER, GEORGE W. and WHITFORD, ROBERT CALVIN. *Readings in Science.* New York: The Macmillan Company, 1931. 283 p. $1.60.

Teachers of English who have been eager to give their students as many vicarious experiences as possible in the style and technique of literature have been handicapped by the lack of available and suitable scientific reading matter. Science teachers, too, who have desired greater correlation between the science and English courses have felt this same handicap in suggesting science reading material suitable for English classes.

Readings in Science consists of a selected series of essays from the literature of natural science. The essays were selected on the basis both of their recognized literary merit and of their scientific value. The authors believe that the essays will prove useful to two groups of students: (1) those interested in science who can be guided to make explorations for themselves in the wealth of authoritative science literature now available; (2) the students using this material in their fourth year English course. Biographical and critical notes together with supplementary questions, exercises, and suggested readings are included. A brief biography of the author precedes each essay. Selections are included from the following authors: Newcomb, Slosson, Smalley, Darwin, Vallery-Radot, Stefansson, Thomson, James, Huxley, Shipley, Beebe, Muir, Sharp, Thoreau and White. —C.M.P.

TAYLOR, GRIFFITH. *Antarctic Adventure and Research.* New York: D. Appleton Company, 1930. 245 p. $2.00.

Much attention has been directed in recent years to Antarctic explorations and research. The feats of Scott, Amundsen, Byrd, and others make a thrilling sequel to those adventuresome explorers of the past. There is this difference, however: while those of a former day were urged on primarily by a love of adventure, fame, or material gain, the latter explorers have had more of a scientific research motive.

Why should a continent which is wholly covered with ice and snow, and which probably will never become the permanent habitation of man nor have economic importance, be the object of so much painstaking research? Not only will research reveal much of the geological history, climate and geography of this vast and practically unknown continent, but a study of meteorological data will add much to our knowledge. A study of the rocks, flora, and fauna will give considerable information about the past history of the earth, the probability of all the continents having been joined together, the probability of the tetrahedral theory of continental balancing, and of great climatic changes in the past.

The author, who is a professor of geography in the University of Chicago, was a member of Scott's last expedition to the Antarctic in 1910-1913 during which Scott reached the South Pole in January, 1912. The book is a popular but authoritative account of various expeditions that have carried on research in the South Polar regions. —C.M.P.

MARMER, H. A. *The Sea.* New York: D. Appleton and Company, 1930. 312 p. $3.00.

In this book, the author has written a popular survey of all that scientific research has discovered about the sea. It is written for the layman and interprets for him one of the most profoundly fascinating aspects of the world in which we live. What do scientists know about the lost continent of Atlantis? the voyage of Leif the Lucky? the Sargasso Sea? the great deeps of the sea? the bottom of the sea? the Gulf Stream? the breaking effect of tides? the actual height of waves? variations in sea-level? icebergs of the Arctic and Antarctic?

Marmer, who is Assistant Chief of the Division of Tides and Currents of the United States Coast and Geodetic Survey, has made a lifetime study of the sea in all its varied aspects. His book is recommended as a popular reference book to those who desire authoritative information regarding the sea. Chapter headings are: "The Sea of Ancient Times," "The Crossing of the Ocean," "Legendary Isles," "The Sargasso Sea," "The Northwest Passage," "The Attainment of the Poles,"

"The Extent of the Oceans," "The Depths of the Sea," "The Bottom of the Sea," "The Level of the Sea," "The Surface Waters," "The Water of the Depths," "Ice in the Sea," "Waves of the Sea," "The Tide," "Tidal Currents," "Ocean Currents," "The Gulf Stream," "The Science of the Sea." —C.M.P.

MAGOUN, F. ALEXANDER and HODGINS, ERIC. *A History of Aircraft.* New York: McGraw-Hill Book Company, 1931. 495 p. $5.00.

This book is probably the most complete history of aircraft that has been written up to the present time and may be used either as a textbook or reference book. For the latter purpose it will serve a most useful purpose in the high-school science library. It is difficult to conceive of any boy or girl who is at all interested in science or aviation not thoroughly enjoying the book.

As the authors state "this book is essentially a record of failures. More than half of its pages are concerned with attempts at flights which ended in disappointment and often disaster." However, final successes were built upon these failures. To record only the former would not present a true history of aviation.

A complete history of all types of aircraft is included: balloons, airships, ornithopters (flapping wings), helicopters, gliders, and airplanes. There are 155 illustrations, together with an invaluable appendix. The appendix gives a chronological record of all airplane and balloon records as to duration, speed, altitude and distance. The chronology of flight record begins with 400 B.C. and concludes with the Post-Gatty circumnavigation of the globe. Nearly six hundred dates are recorded.

—C.M.P.

LEITH, C. K. *World Minerals and World Politics.* New York: McGraw-Hill Book Company, 1931. 213 p. $2.00.

This book embodies a factual study of minerals in their political and international relations. At no time in history has the distribution of the world's mineral resources been at greater importance than it is today. The author, who is a well known geologist has made an extensive study of the mineral resources of the world.

The author believes that the United States has been particularly fortunate in the distribution of mineral resources. The United States has sufficient deposits of practically all of the important minerals, such as sulfur, coal, phosphates, copper, iron, lead, zinc and gypsum. The minerals for which the United States is wholly or mostly dependent upon the rest of the world are: antimony, chromite, potash, manganese, tin, asbestos and nitrates. The author discusses the distribution of minerals, the possibility of exhaustion of present mineral deposits and the discovery of new mineral districts, probable changes due to technology and to substitutions, the mineral position of the nations, and other subjects.

The book is recommended for use as a reference book in chemistry and physical geography classes and to those who are interested in an authoritative discussion of this vitally important subject.

—C.M.P.

MOULTON, FOREST RAY. *Astronomy.* New York: The Macmillan Company, 1931. 549 p. $3.75.

The author attempts to unfold the subject of astronomy by proceeding, step by step, from the familiar earth and evening constellations out to galaxies and supergalaxies of stars. That he accomplishes his purpose is evident from a study of the table of contents, whose chapter headings include: "Preliminary Considerations," "The Constellations," "Telescopes," "The Earth," "The Motions of the Earth," "Time," "The Moon," "Eclipses," "The Law of Gravitation," "The Solar System," "The Planets," "Meteors and Comets," "The Sun," "Evolution of the Solar System," "Stars and Nebulae," and "The Siderial Structure." Twenty-two tables and two hundred thirteen photographic illustrations are included. Questions and references are found at the end of each chapter.

Attention is given to the historical aspects of astronomy, as well as to more recent progress in this field, such as the discovery of the planet Pluto, tests of the

theory of relativity, the size of the universe, and the origin of the solar system. The author proceeds systematically from fundamental principles and observational data to some important final conclusions.

The mathematical phases of astronomy have been reduced to a minimum. Because of its readability, excellent tables, and splendid photographs, the book should appeal to all teachers and laymen interested in the subject of astronomy.

—C.M.P.

HURD, A. W. *Work-Test Book in Physics.* New York: The Macmillan Company, 1930. 148 p. $0.64.

The last two decades have witnessed a steady decrease in the percentage of secondary-school students enrolled in high school physics. In 1915 the percentage of students pursuing physics in the public high schools of the United States was 14.2, whereas in 1922 it was 8.9, and in 1928 it was 6.9. Why has physics enrollment failed to keep pace with the rapid growth in enrollment in our high schools? Science teachers and those interested in science education would welcome a definite answer to this question. Surely a knowledge of physics has not become of less importance in our so-called scientific age. The reasons for this decline in physics enrollment are probably numerous. Many will agree with the reviewer that our methods of teaching need to be changed and that present-day physics textbooks are probably the most poorly written of our secondary science textbooks.

Any change or device that promises better teaching of physics should be welcomed. The *Work-Test Book in Physics* by Hurd is a step in the right direction. The author has devoted many years of study in seeking a solution of the problem of improving physics teaching. The workbook is an outcome of this research. Dr. Hurd believes that we are attempting to cover too much ground in the average physics course with the result that most students are not getting sufficiently clear and definite concepts. More time is necessary in the formation of concepts, and our objectives should be more specific.

Each of the nineteen units in the workbook is based upon some common everyday applications of physical laws. Aims stated as sociological objectives—health, social, avocational, and vocational, together with textbook references, supplementary reading, and suggested project work—are given in each unit. A test covering the subject-matter of each unit is included.

—C.M.P.

STETSON, HARLAN TRUE. *Man and the Stars.* New York: McGraw-Hill Book Company, 1930. 221 p. $2.50.

In *Man and the Stars,* the author presents the story of the adventure of astronomy, from the days when primitive man began to ask himself questions about the meaning of the heavens through the work of the great pioneers of the science to the present day, with its staggering conceptions of the magnitude of the universe. The historical emphasis, which introduces a human touch to the story of astronomy, and a lucidly vivid literary style free from cumbersome scientific terminology, should give this book a wide appeal to laymen and to high school science students.

The author is Director of the Perkins Observatory of Ohio Wesleyan University. The book is divided into four parts. In Part One, "Looking Skyward," the author traces astronomy from its earliest beginnings through the Ptolemaic system of wandering stars. In Part Two, "Changing Concepts," the work of Copernicus, Kepler, Galileo, Newton, Herschel, and others is interestingly portrayed. The third part which deals with "The Changing Universe" discusses such topics as, atoms and stars, the birth of astrophysics, surveying the universe, our changing sun, and cosmic clouds. Part Four treats three questions which man is trying to answer: Is There Life on Other Planets? Has Life Any Cosmic Significance? Has Science Displaced Religion?

—C.M.P.

SHAPLEY, HARLOW. *Flights from Chaos:* New York: McGraw-Hill Book Company, 1930. 168 p. $2.50.

The thesis of this book was presented

in a series of lectures given in New York City during the latter part of 1929. The author, who is Payne Professor of Astronomy and Director of the Harvard Observatory at Harvard University, is one of the world's leading astronomers. In this book he sets forth, for layman and scientist alike, his daring conception of order in the apparent chaos of the universe. The author presents a general and complete classification of all organizations —quanta, electrons, atoms, molecules, organisms, planets, stars, galaxies and supergalaxies—into a unified scheme which points the way to many new interpretations, opens up a panorama of the material universe, evaluates man's place in the physical world, and leads to a clearer concept of the cosmoplasma. A summary of the author's classification of material systems, as well as the diameters and number of particles in each system, is found in the latter part of the book.

The book is calculated to give material for thought as the reader attempts to visualize man's relationships to the infinitely small and the infinitely great. The author brings the order of a unified classification out of what seems to be a chaos of more or less remotely related systems.

—C.M.P.

BROWNLEE, RAYMOND B., FULLER, ROBERT W., HANCOCK, WILLIAM J., SOLION, MICHAEL D., and WHITSIT, JESSE E. *First Principles of Chemistry*. New York: Allyn and Bacon, 1931. 774 p. $1.80.

While this book is based on Elementary Principles of Chemistry by the same authors, it is not a revision of the earlier text. The social service of chemistry, chemical principles, and recent developments that are now influencing the teaching of chemistry receive increased emphasis. Learning exercises have been distributed throughout each chapter rather than at the end. Four sets of short-answer questions, each covering the subject matter of certain chapters, are included at intervals in the book.

Metals receive a very interesting and novel treatment. Instead of being taken up one by one they are presented in chapters dealing with their extraction, physical characteristics, chemical reactions and alloys. The electron theory is introduced early and is used throughout the book. There are 367 illustrations, many of which are line drawings labeled on the cut, a feature which adds much to their usefulness. The illustrations are clear-cut and seem to be well chosen.

Although the text appears to be unduly large, most of the increased space has been taken up by the added illustrations, learning exercises, and general tests.

The authors are high school chemistry teachers with long and successful experience. The practical knowledge they have gained is the basis of a book which merits the continuation of the unusual success accorded their previous text.

—C.M.P.

BROWNLEE, RAYMOND B., FULLER, ROBERT W., HANCOCK, WILLIAM J., SOLION, MICHAEL D., and WHITSIT, JESSE E. *Laboratory Exercises in Chemistry*. New York: Allyn and Bacon, 1931. 282 p.

Although *Laboratory Exercises in Chemistry* is a revised edition, it is to be used with the authors' text *First Principles of Chemistry*. Two commendable changes have been made in the new revision. It contains a complete set of tests covering the entire content of the text, and the pages have been increased in size so that more space is available for writing the answers to questions. Eighty-four experiments are described in the manual.

—C.M.P.

HOLMES, HARRY N., *Introductory College Chemistry*, New York: The Macmillan Company, 1931. 550 p. $3.25.

The revised edition of the author's well-known text is intended to bring the subject-matter up-to-date. Recent progress in industrial processes is emphasized. These processes include the hydrogenation of petroleum, the newer methods of making industrial alcohol, the Bergius' process of liquefaction of coal, and the present methods of nitrogen fixation. The electron concept of the atom, introduced in the second chapter, is used continuously throughout the book. One chapter deals wholly with the structure of matter. References

and questions are included in each chapter.

Although the book is intended for college students who have not had high school chemistry, other students will not find it a dull repetition of their high-school text. The readable type, simple, non-technical style, chapter study outlines, references readings, and up-to-date subject matter should assure this volume a continuation of its previous success.

—C.M.P.

Findlay, Alexander. *The Spirit of Chemistry*. New York: Longmans, Green and Company, 1930. 480 p. $3.00.

Although the title indicates that the book is a popular treatise of chemistry, it is really a textbook. It is intended for those college students desiring a cultural course rather than professional or technical training. The purpose of the book is not so much to impart a detailed knowledge of the subject as to create a scientific spirit, a spirit of toleration, cooperation, intellectual adventure, and intellectual honesty.

The author is a professor of chemistry at the University of Aberdeen and is well known for his earlier text, *Chemistry in the Service of Man*. It is interesting to note that some English chemistry professors as well as American professors believe that courses in chemistry should be differentiated for those pursuing professional courses and those that are unlikely to continue further in a study of chemistry. The author has attained unusual success in the course given by him at the University of Aberdeen, which is the basis for this text.

The chapter headings of the first few chapters in the text indicate the variation from the usual introductory subject matter. A few of these chapters in order are: "The Aim and Method of Science," "The Twilight of Chemistry," "The Dawn of Chemistry," "The Fundamental Laws of Chemistry," "Atomic Weights and the Periodic Law," "Radioactivity and Atomic Constitution," "The Three States of Matter." The electron theory of the structure of matter receives little consideration and is not used in developing the subject-matter. The style and method of treatment are reminiscent of other English textbooks in chemistry. Those interested in making a comparison of English and American texts as to subject matter, method of treatment, and style, will find this a worthwhile text to examine.

—C.M.P.

Weed, Clarence M. *Insect Ways*. New York: D. Appleton and Company, 1930. 325 p. $2.50.

In *Insect Ways* a series of interesting tales about many of the common insects round about us are told by a well-known scientist story-teller. The author relates how ants, bees, butterflies, grasshoppers, wasps, beetles and other insects adapt themselves to their environment: how they secure their food, establish a home, care for the young, communicate with each other, protect themselves from enemies, and pass the winter. Some insects are parasites, some are cannibals, some are artists in camouflaging themselves, some live by mimicry, some have slaves, some have cows, some have communistic social life—all are interesting and have important economic relations.

Biology students and elementary science teachers will find *Insect Ways* a delightful source of information, the former as a supplementary reader and the latter both as a reader and as a source of stories to tell children.

—C.M.P.

News and announcements

The annual meeting of the National Association for Research in Science Teaching will be held at Washington, D.C., on February 22 and 23. The February issue of SCIENCE EDUCATION will contain a complete program of the meetings.

Dr. Georg Roemmert is offering in the Department of Natural Sciences at Teachers College, Columbia University a series of seven lectures in which he is demonstrating the possibilities of micro-projection of living organisms and presenting his methods of procuring and handling organisms for projection purposes. Dr. Roemmert has developed an unusually fine technique in projection work which makes it possible for him to show on the screen many of the fundamental activities of living organisms.

A section of Elementary Science of the Iowa State Teachers Association was formed on November 13, 1931. The purpose of the organization is to study curricular and other problems relating to science in the kindergarten and the first six grades of the elementary school.

The following officers were elected: president, Lillian Hethershaw, Drake University, Des Moines, Iowa; vice-president, Jewel Cutler, Des Moines, Iowa; secretary-treasurer, Romaine Startzer, Newton, Iowa.

For the past year Mr. W. W. McSpadden of the Austin, Texas, Public Schools and Mr. C. C. Raines of the University of Texas have been engaged in the preparation of an inexpensive talking-picture outfit to be used in schools. The February issue of SCIENCE EDUCATION will contain a simple, non-technical description of this outfit which is reported to give results superior to those obtained by the more expensive commercial outfits now on the market.

Professor J. O. Frank has during the past two months addressed three State Teachers Association as follows: Indiana at Indianapolis on October 22, Ohio at Cincinnati on October 30, and Wisconsin at Milwaukee on November 6. Readers of SCIENCE EDUCATION will be interested to know that Professor Frank has published his new book *The Teaching of High School Chemistry.*

The Enoch Pratt Free Library at Baltimore, Maryland, has recently issued, in collaboration with the American Association for the Advancement of Science, a series of book lists in various aspects of the field of science. Each list represents carefully selected references chosen by a committee of specialists in the particular field. Some of the titles of the lists which have appeared are as follows: "Science in the World Today," "The History of Science," "Exploring for Science," "Wonders of the Sky," "The Earth and its Wonders," "Chemistry of Today," "Modern Physics," and "Biology the Science of Life." Twenty-three lists have been received; others are in preparation. One of the forthcoming lists includes references on the teaching of science.

Dr. S. Ralph Powers of Columbia University and Dr. Morris Meister of the

New York Teacher Training College addressed science sections of the Wisconsin State Teachers Association at their meetings during the first week in November.

The Lafayette Air Cadets of the Lafayette Junior High School, Elizabeth, New Jersey, have recently celebrated their fifth birthday. This organization is one of the very active and enthusiastic clubs devoted to aircraft. The work of the club will be discussed in a later issue of Science Education. Our readers should not fail to see this article.

Miss Helen Dolman of the Ypsilanti, Michigan, Teachers College is at present carrying on her work for the Doctorate at Cornell University under the direction of Professor E. Laurence Palmer.

The new officers of the Department of Science Instruction of the National Education Association, elected at the summer meeting at Los Angeles, are as follows: President, Charles Lincoln Edwards, Los Angeles Public Schools, Los Angeles, California; secretary, W. L. Eikenberry, New Jersey State Teachers College, Trenton, New Jersey.

The American Nature Study Society will hold its thirty-fifth annual meeting during the Christmas holidays at New Orleans, Louisiana. A feature of the meeting this year will be an extensive exhibit of nature and elementary science materials.

Dr. S. M. Troxell of the University of Illinois, lately on a research fellowship at the U. S. Bureau of Standards, has begun work in the Science Department of the Trenton, New Jersey, State Teachers College. His particular interest in the new position will be with the physics and chemistry courses offered in this institution.

Mr. J. L. Cooprider, head of the Science Department, Central High School, Evansville, Indiana, is offering during the year, for the third time, a course in applied chemistry. The course is intended primarily for nurses. It was formerly offered in the evening schools of the city but was dropped for lack of funds. The local hospitals appealed to the Board of Education for the re-instatement of the course and are now providing over seventy students in the course.